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MEDIATED TRANSFER IN PAIRED-ASSOCIATE LEARNING

by

Robert William Holmstrom, Jr.

Department of Psychology
Duke University

Date: Oct. 2, 1964

Approved:

Gregory A. Kimble, Supervisor

Robert C. Peterson

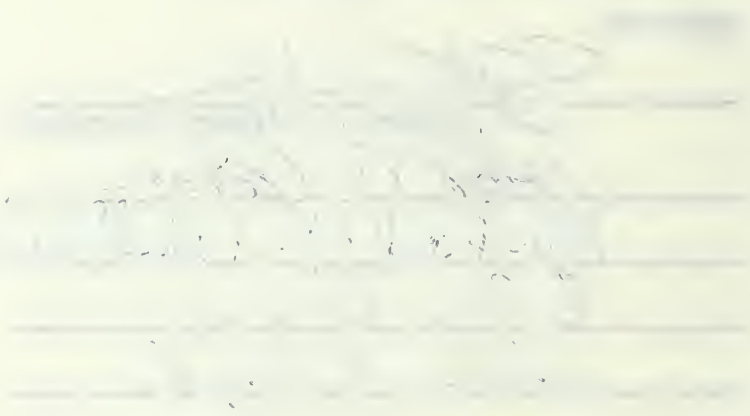
Michael A. Wallach

C. Alan Boneau

Charles A. Baylis

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Psychology in the Graduate School of Arts and Sciences of Duke University

1964



ABSTRACT

(Experimental Psychology)

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ABSTRACT

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The present study attempts to demonstrate both mediated facilitation and interference in the learning and retention of single lists of paired-associates under conditions analogous to the standard retroaction paradigms. Conditions for intra-list facilitation (Positive Condition) are established by pairing identical responses with pairs of associatively related stimuli (List: A-B/A'-B). Conditions for intra-list interference (Negative Condition) are established by pairing different responses with pairs of associatively related stimuli (List: A-B/A'-C).

Two experiments were conducted. In Experiment I, homogeneous lists of eight paired-associates with pairs of stimulus terms having three degrees of associative relatedness were used. The three degrees of associative relatedness were: (1) first associates, (2) second associates, and (3) a non-related or List-Control level. This resulted in a 3 x 2 factorial experiment: two conditions (Positive and Negative) by three degrees of stimulus pair relatedness.

In Experiment I, seventy-two undergraduate females received one study trial and six learning trials. All subjects (Ss) returned forty-eight hours later and received ten recall trials and then relearned the lists to a cri-

terion of one errorless trial. The Immediate-Recall Method for estimating the level of original learning was used in Experiment I.

In Experiment II, eighty undergraduate males received the same procedures as Ss in Experiment I, except that five learning trials were administered so that the Projection Method for estimating the level of original learning used in Experiment II could be compared directly with the Immediate-Recall Method employed in Experiment I. In Experiment II, only the first association Positive and first association Negative Conditions were used.

Facilitation and interference were demonstrated in the learning of A-B/A'-B and A-B/A'-C lists, respectively. Degree of association was not an effective factor in the production of either facilitation or interference. The effectiveness of experimental manipulations was further demonstrated by the finding that S-R pairs which appeared in the lists of the Positive Conditions were learned significantly faster than identical S-R pairs which appeared in the lists of the Negative Conditions. A direct index of mediated interference was provided by the greater than chance frequency of predicted errors (i.e., in List A-B/A'-C, predicted errors are of the type A-C or A'-B) found in the learning of the lists of the Negative Conditions.

The experimental manipulations responsible for facilitation and interference in the learning of the lists did not affect retention of the lists. Recall was high in all conditions of both experiments.

Relearning to a criterion of one errorless trial did result in significantly faster relearning in the Positive Conditions of both experiments. Significant differences in relearning were not obtained when relearning to the level of original learning was the criterion.

An analysis of original learning, recall and relearning in terms of the Two-Stage analysis of verbal learning indicated that the primary focus of

facilitation and interference was the second or associative stage of learning.

Comparisons of the Immediate-Recall and Projection methods showed that the two methods resulted in almost identical estimates of original learning.

The mediation hypothesis of intra-list transfer is discussed and compared with the stimulus-generalization hypothesis of transfer effects. The mediational-linking hypothesis is presented as the most adequate explanation of intra-list interference. The common-concept hypothesis is offered as the most adequate explanation of intra-list facilitation in the present study.

ACKNOWLEDGMENTS

I wish to express my deepest gratitude to Dr. Gregory A. Kimble, my supervisor. His enthusiasm, continuing encouragement and invaluable assistance throughout all phases of this research contributed significantly to whatever is of value here; the author must take responsibility for the remainder.

Special thanks are due to Drs. Leo J. Postman and Geoffrey Keppel for their aid in the development of this study. I am also indebted to Drs. Jack Richardson and William F. Battig for their assistance and comments. To Dr. Donald Burdick go special thanks for his help in many of the statistical analyses of this study.

I am also grateful for the skill and patience of Mrs. Alfreda Kaplan, my typist.

This study was supported, in part, by USPHS grant MH 08090 awarded to Dr. Gregory A. Kimble, and the author's USPHS Predoctoral Fellowship.

R. W. H., Jr.

CONTENTS

ABSTRACT	iii
ACKNOWLEDGMENTS	vi
LIST OF TABLES	viii
LIST OF FIGURES	ix
I. INTRODUCTION	2
II. PURPOSE OF THE STUDY	21
III. METHOD	28
IV. RESULTS	37
V. DISCUSSION	65
VI. SUMMARY	79
APPENDIXES	81
REFERENCES	99

LIST OF TABLES

Table		
1	First Associate Lists in Positive and Negative Conditions	31
2	Mean Correct Responses and Mean Trials to Relearn in Experiment I	39
3	Analysis of Variance of Correct Responses in OL for Experiment I	41
4	Ranked Means of Six Groups for OL in Experiment I	41
5	Analysis of Variance of Correct Responses in Recall in Experiment I	44
6	Ranked Means of Six Experimental Groups at Recall in Experiment I	45
7	Analysis of Variance for Number of Trials to Relearn in Experiment I	47
8	Ranked Means of Six Experimental Groups for Relearning in Experiment I	47
9	Analysis of Variance of Correct Responses in OL for Experiment II	53
10	Empirical and Calculated Probabilities of Correct Response Given N Previous Reinforcements	57
11	Analysis of Variance for Recall Trials in Experiment II	60

LIST OF FIGURES

Figure

1 Experiment I. Mean Number of Correct Responses for OL and Recall--Combined Groups 86

2 Experiment I. Mean Number of Trials Required to Complete Stages One and Two During OL--Combined Groups 87

3 Experiment II. Mean Number of Correct Responses for OL and Recall--Positive and Negative Conditions 88

4 Experiment II. Mean Number of Trials Required to Complete Stages One and Two During OL--Positive and Negative Conditions 89

MEDIATED TRANSFER IN PAIRED-ASSOCIATE LEARNING

Chapter I

INTRODUCTION

The present study represents an attempt to demonstrate both mediated facilitation and interference in the learning and retention of paired-associates under conditions analogous to the experimental designs typically employed in the investigation of transfer and retroaction effects. The design of the present study will also permit investigation of certain characteristics of mediational processes in verbal rote-learning.

The background and general orientation for this study is provided by that area of verbal learning research directly concerned with mediational processes, and, more importantly, by the theory of associative transfer and interference. Current formulations of interference theory assign mediational processes a central role in the analysis of positive transfer, and it has been suggested that mediation may also be the primary mechanism of negative retroaction (Postman, 1961).

The development of the mediation hypothesis of positive transfer followed closely upon the investigation of the two-factor theory of retroactive inhibition (RI).[1] The historical background presented here will accordingly follow the sequence of experimental findings and methodological developments

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1. All standard abbreviations used in this paper are found in Appendix A.

which led to present-day formulations of interference theory, beginning specifically with research in the area of negative retroaction.

Two experiments were conducted in the present study. The preliminary experiment was discontinued halfway through when it became apparent that certain experimental manipulations were not effective. This circumstance permitted the evaluation of two different methods of estimating the level of original learning proposed by Underwood and Keppel (1962). The procedures and results of the two experiments are presented separately following a resume of the relevant historical background and statement of the problem.

Review of Literature

The response-competition or interference theory of forgetting was proposed initially in an analysis of the processes which produce a measurable decrement in the recall and relearning of an original (or first) list following the learning of an interpolated (or second) list. The theory states that: when different or unrelated responses (B and C) are successively associated with identical or similar stimuli, both responses are available at recall and both are elicited by the stimulus. If the two responses are of equal strength at the time of recall, they will block each other, resulting in a retention loss, or RI. If one response is stronger than the other at recall, the stronger response will be given, resulting in RI when the weaker response is the correct one. The central points of this analysis are the following: (1) RI is due to response-competition at recall, either through blocking or in erroneous intrusions, and (2) first-list responses are considered available at the time of attempted recall to compete with interpolated responses which, of course, are also considered available. Such a formulation differs from currently more popular

ones in that it makes no mention of extinction or unlearning of first-list responses as a process which contributes to the production of RI. The line of research which led to the hypothesis of unlearning of first-list responses during interpolated learning (IL) as a mechanism of RI will now be discussed.

Unlearning hypothesis of negative retroaction. The experimental findings which led to the hypothesis that some RI is attributable to the extinction or unlearning of List 1 responses during IL began with investigation of the relationship between RI and degree of IL. The response-competition theory described above would predict a direct correlation between amount of RI and the degree of IL, since, with degree of first-list or original learning (OL) held constant, higher degrees of IL should result in relatively higher strengths of second-list associations at the time of recall. With little competition from List 1 responses, there should be high degrees of RI in the recall and relearning of the first list.

McGeoch (1932) performed the experiment implied by this deduction, using two serial lists of nine low association-value nonsense syllables. OL was constant at eleven presentations of List 1; IL was varied in terms of the number of List 2 presentations: six, eleven, twenty-one and twenty-six presentations, each comprising an experimental condition. Retention was measured by recall and relearning of List 1 to criteria of one and three errorless trials (recall was measured on the first relearning trial).

In both recall and relearning scores, McGeoch found that RI increases with increasing IL, but only in the lower ranges of IL (six to eleven presentations). RI remained constant at higher levels of IL, except for a decrease at the highest (twenty-six presentations) level of IL in the relearning scores. McGeoch concludes that RI does increase with increasing degrees of IL, but that with complete mastery and overlearning of the interpolated list, additional

List 2 learning produces no further increments in RI.

Although response-competition theory might not be hard put to explain an asymptote in the strength of List 2 associations, the study (McGeoch, 1932) itself provides no direct support for the hypothesis that the RI observed is due to response-competition. The term retroactive inhibition simply refers to the observed decrement at the time of recall, and does not refer to a specific forgetting process. Response-competition theory states that RI results from competition between List 1 and List 2 responses. An adequate test of response-competition theory requires some index of response-competition; and confirmation of the theory would require a direct correlation between the amount of RI observed and the index of response-competition.

Melton and Irwin (1940) replicated McGeoch's study, increasing the range of IL, and recording inter-list intrusions as an index of response-competition. Two serial lists of eighteen nonsense syllables were used, OL was constant at five trials; the four experimental conditions consisted of five, ten, twenty and forty presentations of List 2. Measures of retention (i.e., recall and relearning) showed an increase in RI at lower levels of IL, and again a decrease in RI at high levels of IL. The crucial finding for response-competition theory, however, was the failure to find a correlation between RI and inter-list intrusions: there was a considerable amount of RI on the first relearning trial after forty interpolated trials, but only a small fraction of this total RI could be attributed to response-competition since the number of inter-list intrusions was very low. The high degree of RI could not be attributed to blocking since the degree of IL makes the assumption of equal response strength untenable.

These findings led the authors to conclude that a second factor (factor X) also contributed to the production of RI. Since the intrusion records

showed that some responses from List 1 occurred as errors during the early stages of IL, there was reason to assume that List 1 responses were given and unlearned (or extinguished) through differential reinforcement during IL. The RI produced by the unlearning of List 1 responses during IL would dissipate rapidly as List 1 responses are reinforced and relearned, as was found at high levels of IL. The two-factor (unlearning plus interference) theory still falls within the scope of an interference theory, since the "unlearning" of List 1 responses simply changes their strength relative to List 2 responses. A question of recent special interest is whether or not some List 1 responses become totally "lost" or unavailable to the subject (S) during IL (to be discussed below).

Response-competition theory would seem to require some correlation between RI and inter-list intrusions. Thune and Underwood (1943) offered this explanation dealing specifically with this problem: with increasing degrees of IL, list-differentiation (identification of list-membership of the response systems) increases. With increasing list-differentiation, responses from List 2 are more readily recognized as incorrect and are rejected without being produced (implicit intrusions) during the retention test. As greater degrees of list-differentiation develop with high degrees of IL, the ratio of implicit to explicit intrusions increases, resulting in a decline in the number of overt intrusions, exactly as Melton and Irwin (1940) had found. In a study concerned with the list-differentiation hypothesis in paired-associate learning, Underwood (1949) found that Ss could differentiate between lists with high degrees of accuracy immediately following IL, and that the degree of list-differentiation varied directly with the level of IL.

In practical terms related to the conduct of experiments, the fact of list-differentiation means that a test of the unlearning hypothesis now re-

quires a method which would also control for identification of list-membership. Further support for the unlearning hypothesis was obtained in experiments meeting this requirement. These studies (Underwood, 1948a; 1948b) employed paired-associate learning in the study of negative retroaction, with lists constructed so that different responses are paired with identical stimuli in successively learned lists: List 1: A-B, List 2: A-C. In order to control for list-differentiation, a procedure referred to as modified free recall (MFR) was employed. In this procedure the S is presented with the list of stimulus terms after a specified interval following completion of IL, and he is instructed to give a response from either the first or second list (or any other response) with no attempt to discriminate between the two lists. This technique permits the assessment of response dominance independent of list-differentiation. By measuring free-recall at intervals of one, five, twenty-four and forty-eight hours after completion of IL, Underwood (1948b) found that (1) List 2 responses display the typical gradually-declining forgetting curve over a forty-eight hour period; (2) that List 1 responses produce a flat curve which is almost equal to the List 2 response curve after forty-eight hours, and (3) that "other" responses show a steady increase throughout the retention interval.

In the Underwood (1948b) study, there was a nonsignificant rise in the curve of List 1 responses between twenty-four and forty-eight hours. Briggs (1954) did a similar study and obtained a significant rise in the List 1 response curve between twenty-four and forty-eight hours. The major difference between the two studies was that IL immediately followed OL in the Underwood study, whereas in the Briggs study there was a twenty-four hour interval between OL and IL. Both writers conclude that List 1 responses are extinguished during IL and then undergo a process analogous to the "spontaneous recovery" of extinguished conditioned responses. This conclusion is unwarranted since the

MFR technique does not determine whether or not List 1 responses are unavailable or lost at recall (as the term extinction would imply), but only measures response-dominance at recall. Information regarding the availability of List 1 responses was obtained in studies employing a modification of the MFR technique.

The first experiment (Barnes & Underwood, 1959) reported here is important in that both the unlearning and mediation hypotheses of retroaction are investigated, and some of the basic assumptions involved in the present study are derived from its conclusions. Barnes and Underwood used a modified form of MFR (that is, modified, modified free-recall--MMFR) to investigate both the negative (A-B, A-C; stimuli identical, responses different) and the positive (A-B, A-B'; stimuli identical, responses similar) transfer paradigms. In this procedure, the S, after completing IL, is presented with the list of stimuli (A) and instructed to write down: (1) the first response the stimulus brings to mind, (2) the second response (the first and second instructions refer to responses from the lists), and (3) any other response the stimulus brings to mind. Each response is allowed two minutes. Finally, the S is instructed to identify which list (1 or 2) the responses are from. Two lists of ten paired-associates, containing nonsense syllables as stimuli and two-syllable adjectives as responses, were used. Free-recall was measured at the first, fifth, tenth and twentieth trial of IL, each level of IL representing an experimental condition. Results in the A-B, A-C (negative transfer) condition indicated that the number of List 2 responses available at recall gradually increased with the level of IL, whereas List 1 responses showed approximately a 50 percent decline in availability after twenty interpolated trials. Together with the results discussed above, this indicates in summary that (1) under conditions of increasing IL, List 1 responses become increasingly unavail-

able or "lost" (unlearned), but (2) List 1 responses begin to recover associative strength after an interval of twenty-four to forty-eight hours after interpolation, even at very high levels of IL.

Postman (1963) reports unlearning of List 1 responses in studies using lists composed of trigram pairs and lists composed of paired adjectives. McGovern (1964), in a recent study, has demonstrated that the unlearning of both forward (S-R) and backward (R-S) List 1 associations contributes to the production of RI. The demonstration of unlearning in both forward and backward associations, and with a range of verbal materials, lends considerable support to the unlearning hypothesis of negative retroaction.

In summary, experimental evidence has supported the hypothesis that the major source of forgetting in the A-B, A-C paradigm is the unlearning of List 1 responses during IL. The unlearning process has become central to current interpretations of forgetting, since it is now apparent that the acquisition of new verbal habits can result in the modification of previously acquired habits, rather than simply producing competition between old and new habits. If List 1 responses do spontaneously recover as reported above, then increasing competition between List 1 and List 2 responses would be expected twenty-four to forty-eight hours after IL. A recent study by Koppenaal (1963) has cast doubt upon the spontaneous recovery hypothesis, however, by demonstrating that List 1 responses show no recovery, either in relative or absolute terms, when the List 1 response curve is compared with the results obtained when Ss learn only one list. This finding suggests that List 2 in the A-B, A-C paradigm suffers Proactive Inhibition (PI: the slower learning and inferior recall of a second list following the learning of a first list, compared to a condition in which only the second list is learned). PI would presumably result from elicitation of the competing List 1 response (B) in the initial stages of

List 2 learning.

The following discussion of the mediation hypothesis of positive retroaction will show that mediational processes are also a third possible source of forgetting.

The mediation hypothesis of positive retroaction. In the positive transfer paradigm, two similar or related responses are paired with identical stimuli in successively learned lists: A-B, A-B'. Learning the A-B' list after learning the A-B list results in recall and relearning scores on the A-B list superior to the comparable scores of the control condition in which only the first A-B list is learned and recalled.

Prior to the response mediation interpretation of Barnes and Underwood (1959) many interference theorists held that response generalization was the basic mechanism of positive retroaction (Osgood, 1946, 1948; Morgan & Underwood, 1950; Hughes & Underwood, 1950; Young, 1955). This interpretation was based on the assumption that when a response B is learned to stimulus A, other responses (B') similar to B also develop some associative strength to A. The strength of the association formed between A and B' through parasitic or generalized reinforcement varies directly with the similarity of B' to B. Proactive positive transfer (i.e., faster learning and superior recall in learning A-B' after learning A-B, than in learning and testing A-B' without first learning A-B) is produced by the strengthening of A-B' associations during the learning of A-B. In the retroaction design, the original A-B associations are further strengthened by generalized reinforcement during IL. When the two lists are learned to approximately the same criterion, positive retroaction occurs because the associative strength of the A-B pairs at recall is greater than that of the A-B' pairs. This difference in strength at recall is due to the fact that in the case of the original A-B associations, generalized reinforcement

occurs (from A-B' to A-B during IL) after List 1 (A-B) associations have reached the learning criterion (when the A-B associations are learned and are at a high level of associative strength), whereas generalized reinforcement of A-B' from A-B occurs during OL, before the A-B' associations reach the learning criterion, and are only in the process of being established.

The response generalization theory has received support in the experiments of Osgood (1946, 1948), Morgan and Underwood (1950), Underwood and Hughes (1950) and Young (1955). In general, the studies cited above report decreasing amounts of RI with increasing inter-list similarity,[1] using lists composed of adjective pairs or nonsense syllable-adjective pairs. Perhaps the most impressive of these is the finding of a generalization gradient by Underwood and Hughes (1950). Subjects learned a single list of ten nonsense syllable-adjective pairs of low intra-list response similarity for five learning trials, each learning trial followed by a single recall trial, with a final recall trial one week later. The authors found that the more similar (as rated by judges) an error was to the correct response, the more frequently that error occurred, indicating that associative strength from reinforced (i.e., correctly anticipated) responses had generalized to similar responses, with the most similar (erroneous) responses receiving the greatest increments in associative strength.

Experimental evidence has generally supported the response generalization theory of retroactive facilitation. However, the predictions which follow from response generalization theory are not supported in studies investigating the relationship between response similarity and PI. Response generalization

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1. Similarity will always refer to meaningful, rather than formal, similarity.

theory would predict increasing PI (interference in the recall of a second or final list) when successively learned lists of increasing response similarity are learned to the same performance criterion. Responses learned in the first list should, for the reasons presented above, gain further associative strength as successive lists of increasing response similarity are learned, resulting in interference in the attempted recall of the second or final list. Morgan and Underwood (1950) and Young (1955) tested this hypothesis using three successive lists of increasing response similarity. The predicted increase in PI was not found in either case, suggesting that some other factor was minimizing response competition at recall. Recent evidence suggests that mediational processes may be the "factor" responsible for minimizing response competition. The mediation hypothesis of retroactive facilitation is presented below.

The Barnes and Underwood (1959) study reported above investigated both the positive (A-B, A-B') and negative (A-B, A-C) transfer paradigms, employing the method of MMFR to determine response dominance and availability at four levels of IL. In the positive transfer condition, the important results are the following: (1) There was no decline in List 1 (A-B) responses at all levels of IL, and almost perfect recall of List 2 (A-B') responses. (2) Direct positive transfer from List 1 to List 2 was evident in the first recall trial: after one interpolated trial, learning of the second list was almost perfect. (3) Throughout recall, List 1 responses were given first significantly more often than List 2 responses (indicating that List 1 responses remained dominant throughout interpolation, although this tendency decreased with higher levels of IL). (4) List-differentiation was very accurate at all levels of IL. These findings were interpreted as supporting the hypothesis that the acquisition of A-B' during IL was mediated by the response chain A-B-B'. Direct support for this hypothesis came from the Ss themselves: ninety-four of the ninety-six Ss

reported using B to mediate the second-list pair A-B'. The four major findings listed above are all adequately explained by this hypothesis, since the use of the A-B-B' chain during List 2 learning would result in the continued strengthening of the A-B associations during interpolation and make them readily available for recall.

Although the results of this study do not directly contradict the predictions that would follow from the response generalization hypothesis, the authors conclude that the mediation hypothesis is the most adequate explanation of their results. Mediation, as generally conceived, occurs on the basis of associative relatedness (Underwood, 1961, p. 213), rather than on the basis of (response) similarity. This distinction, however, does not affect the mediation hypothesis since Haagen (1949) has shown that ratings of similarity correlate very highly ($r = .90$) with ratings of associativeness. Words similar in meaning, then, are generally associated (in terms of rated association); therefore the conditions necessary for mediation did exist in the Barnes and Underwood (1959) study. As mentioned above, the mediation hypothesis can account for the failure to find increasing PI with increasing response similarity in the studies of Young (1955) and Morgan and Underwood (1950), since the high degrees of response similarity could result in the mediated learning of subsequent lists, effectively reducing PI.

The issue of mediation vs. generalization in the production of positive transfer will be considered again in the discussion section of this dissertation. One final comment in this connection concerns a conception proposed by Postman (1961) regarding the relation between the two mechanisms of transfer: mediation and unlearning. Postman speculates that perhaps mediation is the basic mechanism and unlearning a secondary one; mediation may always occur in the early stages of List 2 learning, so that in the A-B, A-C condition, an

A-B-C chain would be used in learning the second list. This would probably be unsuccessful and result in errors of the type B', that is, rather than the A-B association leading to the correct response C, A-B would lead to (incorrect) responses similar or related to B. The conditions of the present study designed to produce mediated interference permit an evaluation of the occurrence of exactly this type of mediated error.

The following section will consider mediational processes in paired-associative learning in more detail and will raise questions regarding mediational processes which are of direct concern to the present study.

Characteristics of verbal mediation. The classic mediation paradigm states that if an element A is associated with a second element B, and B in turn is associated with some third element C (never directly associated with A), then A will have some association with C. Without the elicitation of the common response B, the response C would not be elicited (or would be elicited less frequently) by stimulus A. Experimental investigations have provided conclusive evidence for mediated inter-list facilitation with one-, two-, and three-stage mediational links in a variety of mediational paradigms (Horton & Kjeldergaard, 1961; Jenkins, 1963). Both experimentally acquired associations (Bugelski & Scharlock, 1952) and pre-experimentally acquired associations (Russell & Storms, 1955) have been used as conditions for mediation. In the Barnes and Underwood (1959) positive transfer study presented above, responses selected on the basis of rated similarity served as the basis for mediation, and Postman (1963) reports successful use of mediational chains of the type A-B-C (in the A-B, A-C paradigm) when pairs of nouns are used as learning materials.

Using pairs of medium association value nonsense syllables, Bugelski and Scharlock (1952) demonstrated facilitation in paired associate learning in

a single-stage mediation paradigm: experimental Ss first learned two lists A_1-B_1 and B_1-C_1, then were tested on an A_1-C_1 list; results were superior to control conditions in which lists of the type A_1-B_1, B_1-C_1 and A_1-C_2 were used. Russell and Storms (1955) extended the Bugelski and Scharlock findings in a two-stage paradigm using mediational links inferred from free association norms (Russell & Jenkins, 1954). All Ss first learned an A-B list constructed so that B has as a primary associate a third element (word) C, which in turn elicited D as a first associate, although D was not an associate of B (or A). In the experimental condition, the test list was composed of A-D pairs; in the control (non-mediated) condition, the test list was composed of A-X pairs, (X having no associative connection with either B, C, or D). As predicted, performance was superior in the experimental (mediated) condition. The interpretation of these results is difficult, however, in that it is impossible to determine whether or not the superior performance in the experimental condition was the result of mediated facilitation, or due to interference in the control conditions resulting from the elicitation of C and D during attempted learning of the A-X (test) list. However, errors of the type C or D were infrequent in test list learning in the control conditions, suggesting mediated facilitation was the major factor.

Russell and Storms (1955) point out that simply demonstrating facilitation does not explain how mediational processes achieve the observed effects. For example: does specific response linking actually occur? Are free-association norms critical in predicting mediation effects, or are the effects due to some other, related characteristics of verbal units?

McGehee and Schulz (1961) attempted to answer these and other questions in a study which employed the Russell and Storms two-stage associative links as conditions for mediation. They were particularly concerned with the follow-

ing questions: (1) does mediation produce absolute positive transfer (when compared with a control list which does not contain potential mediated interference); (2) can mediated interference be demonstrated; (3) are free-association norms critical in the prediction of mediational effects, and (4) how are the mediational effects achieved?

The fourth question regarding how mediational effects are achieved was approached by McGehee and Schulz (1961) in terms of a general analysis of verbal learning initially proposed by Underwood and Schulz (1960). This analysis conceives of verbal learning as a two-stage process. In the first, or response-recall, phase the response unit itself is learned and made readily available for recall, independent of any relation to its proper stimulus. In the second, or associative, phase the response, now learned, has to be associated with the proper stimulus. Although logically distinct, these processes undoubtedly overlap in an actual learning situation.[1] With regard to the issue of how mediational processes produce facilitating effects in the A-B, B-C-D, A-D paradigm, two equally plausible hypotheses are possible in terms of the two-stage analysis. First: mediational links result in faster learning because the second or associative phase of learning is facilitated. The specific associative connections existing among the implicit responses reduce considerably the processes involved in learning to associate the response with the proper stimulus. In short, the inferred B-C-D chain provides a direct route for the learning of the A-D (test list) association. Second: faster learning occurs because of facilitation in the first or response-recall phase. Learning the original A-B list would raise the associated D response in the S's response

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1. This two-stage analysis can also be applied to forgetting: loss of S-R associations can be due to either (1) a failure to recall the correct response itself or (2) the response is correctly recalled but the appropriate stimulus is forgotten (McGovern, 1964).

hierarchy, making the response more readily available than if the B response had not been learned. The enhanced availability of the D response could facilitate learning independent of specific associative chaining: Underwood, Runquist and Schulz (1959) have shown that paired-associate learning is facilitated when response availability is enhanced through pretraining.

The study conducted by McGehee and Schulz (1961) reports the following findings regarding the questions raised above: (1) With regard to absolute positive transfer, although significant facilitation was obtained when conditions identical to Russell and Storms's (1956) Mediated (First List: A-B, Inferred Chain: B-C-D; Test List: A-D) and Non-Mediated (A-X, X-Y-Z; A-D) conditions were compared, there was no evidence of absolute positive transfer when the Mediated Condition was compared with a Practice-Control Condition (A_1- X, X-Y-Z, A_2-D; test-list stimulus A_2 should <u>not</u> elicit the X-Y-Z chain associated with A_1). (2) Mediated interference was demonstrated in the superior performance of the Non-Mediated Condition (see above) when compared to an experimental condition in which the first list was identical to the first list of the Mediated Condition, but the test list consisted of a random re-pairing of the responses with the appropriate stimuli (A_1-B_1, B_1-C_1-D_1, A_1-D_5). Here mediation presumably results in the elicitation of D_1 which would compete with D_5 during test list learning; however, data regarding the occurrence of errors of the type D_1 during test list learning are not reported. (3) Free-association norms were reported as critical as predictors of mediational effects in that no differences were found between the Non-Mediated Condition and a condition in which the order of learning of the first and test lists of the Mediated Condition was reversed. The logic here was that if the associative connections provided by free-association norms is unidirectional, reversing the order of the lists in the Mediated Condition should eliminate most, if not all, of

the facilitation. On the other hand, if some other, more general, relationships (e.g., inter-list similarity)--which are not necessarily unidirectional--are responsible for facilitation, then the Reverse-List Mediation Condition should be at least superior to the Non-Mediated Condition, if not equal to the standard Mediated Condition. The failure to find superior performance in the Reverse-List Mediated Condition (as compared to the Non-Mediated Condition) is interpreted as meaning that the associative norms were critical in the production of facilitation. This finding is in conflict with a study conducted by Storms (1958) which reports evidence for bidirectionality with normatively unidirectional associations as mediating links, although in the Storms study forward associations did produce greater facilitating effects. Storms, however, employed a one-stage mediation paradigm, whereas the McGehee and Schulz study used a two-stage paradigm. (4) The availability hypothesis (i.e., that mediation achieves its effects via facilitation of the first, or response-call, phase) was not supported. This hypothesis was tested by comparing an Availability Condition (A_1-B_1, B_1-C_1-D_1, A_2-D_1) with the Practice Control Condition (see above). If facilitation occurred via enhanced response availability, then learning the A_1-B_1 first list should raise D_1 (via B_1-C_1-D_1) in the Ss' response hierarchy so that it would be more readily available for association with stimulus A_2 of the test list. The authors conclude that the superior performance in the Mediated Condition resulted from facilitation of the associative stage of learning.

In summary, the results of the McGehee and Schulz (1961) study indicate that (1) absolute inter-list facilitation in a two-stage mediation paradigm is difficult to demonstrate relative to stringent control conditions; (2) mediated interference can be demonstrated using a response re-pairing technique; (3) free-association norms appear to be critical as predictors of mediation

effects and operate unidirectionally in a two-stage mediation design; and (4) the faster learning of the test list was not due to facilitation of the response-recall phases of verbal learning, but rather to the facilitation of the associative-phase via specific mediating links.

The studies above were considered in some detail because they concern issues relevant to the present study. Before proceeding to a presentation of the purpose of the present study, a brief summary of this section is in order.

Summary. The unlearning hypothesis of negative retroaction has received firm empirical support in studies employing an appreciable range of verbal materials. The "spontaneous recovery" of List 1 associations is presently in doubt since the finding that the comparison list (List 2) suffers PI from List 1 learning (Koppenaal, 1963). The A-B, A-C condition is considered the basic unlearning paradigm: given identical stimuli, the subsequent learning of new (different) responses results in the unlearning of responses previously associated with the stimuli. This unlearning can occur either in terms of a "loss" of the response itself, or in terms of forgetting the appropriate stimulus for the response, or both. Postman (1963) has reported successful use of the mediational chain A-B-C in the A-B, A-C unlearning paradigm with certain verbal materials and has pointed out that unsuccessful attempts to use mediation in the unlearning paradigm should result in errors of the type B'.

The mediation hypothesis of positive retroaction has been successfully demonstrated in the Barnes and Underwood (1959) study: in the A-B, A-B' paradigm, retention of the List 1 is enhanced through use of the mediational chain A-B-B' during interpolation. The response generalization interpretation of inter-list facilitation in the A-B, A-B' paradigm has not been refuted, but the high correlation between (rated) similarity and associativeness makes a critical experiment difficult.

The essential conditions for mediational chaining is associative relatedness, and McGehee and Schulz (1961) report that facilitation is achieved (at least in a two-stage paradigm) via specific associative links. The same authors report that associative norms are critical in the production of facilitation, although Storms (1955) found evidence for bidirectionality of associates in a one-stage mediation paradigm. McGehee and Schulz (1961) were also able to demonstrate mediated interference by using a response re-pairing procedure.

Chapter II

PURPOSE OF THE STUDY

The general design of the present experiment will be presented here in order to facilitate the discussion of the issues relevant to the purpose of the study. The main experimental conditions will be discussed first.

The present study is concerned with the demonstration of mediated facilitation and interference in the learning and retention of single lists of paired-associates. The main experimental conditions of the present study were derived from the positive and negative transfer paradigms discussed above.

Positive Condition

The Positive Condition of the present study is analogous to the positive retroaction paradigm. In the inter-list transfer paradigm, identical stimuli are paired with similar or related responses in successively learned lists (A-B, A-B'); in the Positive Condition of the present study, identical responses are paired with associatively related stimulus pairs within a single list (List: A-B/A'-B). In the A-B, A-B' paradigm, the conditions for mediation are provided by the relation (associativeness or similarity) between responses in the two lists; in the present study, the conditions for mediation are provided by the associative relatedness between stimulus pairs within a single list, so that mediational chains of the type A-A'-B or A'-A-B are possible.

The Positive Condition of the present study, then, is designed to produce intra-list facilitation, resulting from mediation via pairs of associatively related stimulus terms.

Negative Condition

The Negative Condition of the present study is analogous to the negative retroaction condition. In the A-B, A-C paradigm, identical stimuli are paired with different or unrelated responses in successively learned lists; in the experiments reported here, different responses are paired with associatively related stimulus pairs within a single list (List: A-B/A'-C). In the negative inter-list transfer paradigm, pairing different responses with identical stimuli in successively learned lists results in interference and unlearning of the first list. In the present study, pairing different responses with associatively related stimulus pairs (within a list) is expected to result in mediated interference: for example, given the pairs A-B/A'-C, stimulus-linking chains of the type A-A'-C or A'-A-B are possible (although associative norms indicate the first type is more likely than the second, as will be discussed in a later section). These mediational chains result in errors or intrusions. With regard to A-B/A'-C, the occurrence of response C to stimulus A, or B to stimulus A', will be referred to as "predicted errors." Predicted errors will provide a direct index of mediated (intra-list) interference expected in the Negative Conditions of the present study. Although the Negative Conditions are not designed to deal with the unlearning of stimulus-pair associations (since these associations are expected to produce interference), it is not unreasonable to assume that some (temporary) blocking or inhibition of stimulus associations might be required to

learn the lists. In this regard, the major difference between the A-B, A-C paradigm and the Negative Conditions here is that stimulus differentiation is possible in the present study. The related stimuli are distinct, even though associated, whereas the A-B, A-C paradigm employs the same stimulus in both lists, so that the S is required to learn two different responses to one stimulus (the list-differentiation hypothesis proposed by Thune and Underwood [1943] refers only to the list-membership of responses). The relevance of the unlearning hypothesis for the present study lies primarily in the fact that the unlearning paradigm has provided the basis for the Negative Conditions in this experiment. The relation between unlearning and mediation is of some relevance here in that (as discussed above) if Postman's speculation is correct and mediation is the primary mechanism of transfer, then an A-B-C mediational chain would produce (mediated) errors of the type B'. The Negative Condition of the present study is expected to result in mediational chains which produce the equivalent of type B' errors, here referred to as predicted errors.

Mediation

The design of the present study will permit evaluation of certain questions regarding mediational processes in paired-associate learning. The present study used free-association norms (Russell & Jenkins, 1954) to obtain known degrees of associative-relatedness between stimulus pairs. An important question would be whether or not associative norms are critical in the prediction of mediated effects for the conditions of this study. There are two approaches to this question here. First, with regard to both the Positive (A-B/A'-B) and Negative (A-B/A'-C) Conditions, one of the two related stimuli

(A and A') is always a free-association stimulus word to which associations were obtained in deriving the norms. These main stimulus words are represented by A in the diagrams above. The associate of A is represented by A', e.g., in the stimulus-pair TABLE and CHAIR, A represents TABLE, the free-association stimulus word; A' represents CHAIR, the first associate of TABLE. Stimulus-response (S-R) pairs which contain A stimuli will be referred to as A-pairs, and A'-pairs will refer to S-R pairs which contain A' stimuli. Comparisons between A-pairs and A'-pairs will provide information regarding the effects of directionality of associates in predicting mediated effects. Differences would be expected since it is known that the tendency for A to elicit A' is greater than the tendency for A' to elicit A.

The second approach to the question as to whether or not free-association norms are critical involves an experimental manipulation employed in the first experiment (Experiment I) of this study. In Experiment I, the degree of association between stimulus pairs was varied, resulting in two levels of stimulus-pair relatedness and a control level. The first level is composed of main stimulus words and their first associates, A and A_1'; the second level consists of the identical main stimulus words used in the first association list and their second associates, A and A_2'; the third or List-Control levels can be diagrammed as follows: the Positive List-Control A-B/ D-B, the Negative List-Control A-B/ D-C; where A and D are not associatively related. This design permits comparisons of lists containing first associates with lists containing second associates (the lists are otherwise identical). If degree of association is a critical factor in predicting mediating effects, the following predictions can be made. First, in the Positive Condition, performance in learning, recall and relearning should vary directly with degree of association; that is, fastest learning and superior recall in the first-

association list, and slowest learning and poorest recall in the control list. In the Negative Condition, learning and recall should vary inversely with degree of association: fastest learning and best recall in the control list, with the poorest performance predicted in the first-association negative list. The Positive and Negative List-Control Conditions should not differ in learning and recall, since stimulus pairs are not associatively related.

Both Experiment I and Experiment II provide information regarding the issue of associative directionality; Experiment I provides information regarding degree of association.

A further question regarding mediational processes concerns the stage or phase of learning primarily involved in the production of facilitation or interference. The design of the present study would indicate that the second or associative stage would be the critical factor in the learning of the lists. The responses used in the present study are nonsense syllables; each list contains eight stimulus terms (four pairs of related stimuli), and four responses, each used twice. The same four responses are used in all conditions. Response learning is not expected to differ in the Positive and Negative Conditions; the associative phase of learning is expected to be significantly more difficult in the Negative Condition. The experiments presented here will permit reasonable estimates of the completion of the first and second stages of learning, so that the appropriate comparisons can be made.

This investigation of intra-list transfer will also permit comparisons of certain S-R pairs which appear in both the Positive and Negative Conditions. These S-R pairs will be referred to as Identical Pairs. Comparisons of Identical Pairs across conditions can indicate whether or not fortuitous associations between stimulus and response terms contribute to the effects obtained. S-R pairs in the Positive Condition should be learned faster than the

identical S-R pairs in the Negative Condition.

The present study is also concerned with the nature or content of the mediational processes which are assumed responsible for facilitation and interference. This issue is, of course, related to the questions raised above regarding the criticalness of associative norms. The studies reported earlier have generally assumed mediation to occur via specific associative linking, such as A-B-B' in the A-B, A-C paradigm, or the two-stage A-B-C-D chain in the McGehee and Schulz (1961) study. The experiments of the present study assume that associations between stimulus pairs provide the conditions for mediation.

The experiments in the present study will permit evaluation of the nature of mediational processes by means of the following information: (1) comparing first and second association groups within each condition (i.e., Positive and Negative); (2) comparing A-pairs and A'-pairs within conditions; (3) the occurrence of predicted errors in the Negative Condition, and (4) comparisons involving stage-one and stage-two learning within and across conditions. The relevance of these results for the evaluation of mediational processes will be discussed below.

Retention

The present study will also determine the effects of mediated facilitation and interference on the retention of verbal materials. A retention interval of forty-eight hours was selected primarily because of the reports of "spontaneous recovery" occurring between twenty-four and forty-eight hours after IL in the negative retroaction condition (Barnes & Underwood, 1959; Briggs, 1954). If processes similar to unlearning do occur with associates in the Negative Condition, then a forty-eight hour retention interval should permit evaluation of any "recovery" effects.

Those processes considered responsible for facilitation and interference in learning are also expected to produce facilitation and interference in retention. Two methods of controlling for differences between groups in terms of rate of original learning are employed. The greatest forgetting is predicted in the Negative Conditions, and the least forgetting is predicted in the Positive Conditions, with intermediate amounts of forgetting predicted in the List-Control Conditions of Experiment I.

Chapter III

METHOD

The method and specific procedures of the experiments conducted in the present study will be presented following a discussion of a more general methodological problem involved in the study of retention.

Measurement of Original Learning

Assessment of experimental manipulations on the retention of verbal materials requires an accurate measure of the level of learning attained prior to the retention interval. In many studies of retention, the number of correct responses given on a final learning trial is used as a baseline from which recall scores are subtracted to obtain retention scores. Underwood (1954) and Underwood and Richardson (1957) have pointed out the inadequacies of this procedure. The difficulties here arise from the fact that the number of correct responses given on any particular trial does not indicate the level of learning attained on that particular trial, but rather indicates what was correctly recalled from the immediately preceding trial; this measure does not indicate any changes in the level of learning (whether an increase or a decrease) that might occur on or during the final learning trial on which the scores are obtained. If the number of responses correctly anticipated on the last learning trial is used as the baseline for measuring retention, this measure will be in error to

the extent that the level of learning changes during the final learning trial. If two conditions are being compared in which the rate of original learning differs, the error in measuring the level of learning in the two conditions will differ, and comparisons of retention will be confounded. The critical measure required, then, is one that will determine the actual level of learning finally attained, including the learning (or change in level of learning) that occurs during the final learning trial.

Underwood and Keppel (1962) propose two general methods for accurately determining the level of original learning in studies of retention. The first of these methods involves the use of recall-control Ss. This procedure can be illustrated as follows: if each experimental S receives five learning trials, an equal number of recall-control Ss also receives five learning trials under identical conditions. Immediately following completion of the five learning trials, the recall-control Ss receive one recall trial, in which only the stimulus terms of the pair are presented and the S is required to give the response. The number of correct responses given by the recall-control Ss on the immediate recall trial indicates the level of learning attained on the fifth learning trial. The scores of the immediate recall-control Ss are then used as the baseline for measuring the retention of the experimental Ss (who do not receive the immediate recall trial). The immediate recall procedure provides the mean number of responses learned in each experimental condition, and the mean is used in obtaining retention scores. The immediate recall method was used in Experiment I of the present study.

The second procedure, originally proposed by Underwood (1954), is referred to as the Projection Method. This procedure involves a successive probability analysis of group data which provides the probability of a response being given correctly on some subsequent trial given that it has received 0, 1,

2 . . . n previous reinforcements.[1] This procedure does not require control Ss, but does require at least thirty Ss in each experimental condition to insure accurate probabilities. The details of this procedure are presented in the Results section (below). In essence, this method permits an estimate of the level of learning attained on the final learning trial on the basis of each S's performance on all the learning trials preceding the final trial.

The Projection Method was used in Experiment II. By using the appropriate number of learning trials in each experiment, a comparison of the two methods of estimating the level of original learning is possible.

General Procedure

As reported above, two experiments were conducted in the present study. Experiment I will be described here, and the difference between Experiments I and II will be presented in detail below.

Experiment I contains two main conditions, the Positive Condition (in which mediated facilitation is predicted) and the Negative Condition (in which mediated interference is predicted). To establish these conditions, homogeneous lists of eight paired-associates with pairs of stimulus terms having three degrees of associative relatedness were used. In the Positive Condition, related stimulus terms were paired with identical responses, so that the S was required to learn one response to two related stimuli (A-B/A'-B). In the Negative Condition, related stimulus terms were paired with different responses, so that the S was required to learn two different responses to two related stimuli (A-B/A'-C). All lists (Positive and Negative) contain four

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1. A correct anticipation is considered a reinforcement.

different responses (nonsense syllables), each used twice. The three levels of stimulus pair relatedness were established through free-association norms (Russell & Jenkins, 1954): (1) first associates, (2) second associates, and (3) a List-Control or non-related level, in which there is no associative relationship between stimulus pairs. This design results in a 3 x 2 factorial experiment: three levels of stimulus relatedness, by two conditions (Positive and Negative). The simplest way to present this design is to give a list of the materials used.

Table 1

First Associate Lists in Positive and Negative Conditions[1]

Stimuli	Responses (+)	Responses (-)
TABLE	BIW	BIW
CHAIR	BIW	GEJ
HAMMER	GEJ	RUQ
NAIL	GEJ	ZAF
DARK	ZAF	GEJ
LIGHT	ZAF	RUQ
KING	RUQ	ZAF
QUEEN	RUQ	BIW

The second associate list is established by substituting the appropriate second associates (A'_2) in place of the first associates (A'_1). Similarly, for the List-Control Groups, non-related words are substituted for A' words.

1. See Appendix B for a complete presentation of the Lists.

This procedure holds, of course, for both the Positive and Negative Conditions.

Each of the six lists comprises an independent experimental condition. Experiment I was originally designed to have twenty-four Ss in each condition, giving a total of 144 Ss. In each of the six conditions, twelve Ss were to be Experimental Ss, and twelve Ss were to serve as Immediate-Recall Control Ss for determination of original learning. Experiment I was discontinued when exactly half the number of Ss originally intended had completed the experiment.

In Experiment II, the second association and List-Control groups of both conditions (Positive and Negative) were eliminated, leaving only the first association Positive and Negative Conditions. This change was made when it was discovered that (1) degree of association between pairs of stimulus terms was not an effective factor in either the Positive or Negative Conditions, and (2) the List-Control groups performed as predicted, intermediate between the Positive and Negative Association groups. Experiment II employed the Projection Method for determining the level of original learning; this method requires at least thirty Ss in each condition. Forty Ss were used in each condition of Experiment II, resulting in a total of eighty Ss. Other differences between the two experiments will be described under the appropriate headings.

Lists: Experiment I. The stimulus words and their associates were obtained from the Russell and Jenkins (1954) free-association norms. Items were selected which had first associate frequencies of 60 to 80 percent and second associate frequencies of 5 to 10 percent. Words with low second associate frequencies were deliberately selected in order to provide a steep gradient of stimulus pair relatedness. Care was taken in the selection of stimulus words to insure there were no obvious associations among the words other than those required. List-control words for the third (or non-related) level were se-

lected which had no apparent relation to other stimulus words, and were all high-frequency words (Thorndike & Lorge, 1934). Four nonsense syllables of low association value (10 to 30 percent) were selected from Glaze (Underwood & Schulz, 1961). Intra-list response similarity was low in that no vowel or consonant was used more than once.

In order to minimize the effects of any fortuitous associations between stimulus and response terms (or to detect possible significant effects of fortuitous associations), two different pairings of responses were used (hereafter referred to as List A and List B), maintaining the appropriate pattern within conditions.

In the Negative Condition, special care was taken in pairing the four responses with the eight stimulus words. First, of course, the same response could not be paired with two related stimuli. Second, no two sets of stimulus pairs were paired with less than three different responses. This was to prevent possible facilitating effects that might result if this last restriction were violated in the following way: TABLE-BIW, CHAIR-GEJ, and HAMMER-BIW, NAIL-GEJ. Here, two sets of stimulus pairs are paired with only two different responses. The restriction employed requires that at least three different responses be paired within any two sets of related stimulus pairs (e.g., TABLE-BIW, CHAIR-GEJ, and HAMMER-BIW, but NAIL-ZAF).

Also in the Negative Condition, responses were paired so that equal numbers of A-pairs and A'-pairs could be directly compared with identical S-R pairs in the Positive Condition.

Lists: Experiment II. The Lists in Experiment II were identical to the lists of the first association Positive and first association Negative Conditions of Experiment I. Both List A and List B were used in Experiment II.

Subjects: Experiment I. A total of seventy-two female undergraduates served in Experiment I, twelve Ss in each of the six experimental conditions. Six of the twelve Ss in each condition served as Immediate-Recall Control Ss. Within each of the six conditions, equal numbers of Experimental and Immediate-Recall Control Ss received Lists A and B. Subjects were assigned randomly to the six conditions as they appeared for the experiment. None of the Ss had previously served in a verbal learning experiment. Subjects were Introductory Psychology students at Duke University for whom experimental participation was a course requirement.

Subjects: Experiment II. Eighty male undergraduates served in Experiment II, forty in each of the two (first association Positive and first association Negative) conditions. Twenty Ss received List A and twenty Ss received List B in both conditions. Subjects were assigned randomly to conditions as they appeared for the experiment. None of the Ss had previously served in a verbal learning experiment. The Ss were obtained from Introductory Psychology courses at Duke University which required experimental participation.

Procedure: Experiment I. The lists were presented in a standard memory drum at a 2:2 second presentation rate with a four second inter-trial interval. Four semi-random orders of the lists were constructed with the following two restrictions: (1) related stimulus words never appeared twice in succession, and (2) the same response never appeared twice in succession. All Ss were given standard instructions for anticipation learning of paired-associates.[1] The Ss were instructed to spell the responses aloud, and were told they could guess. They were not told that stimuli were paired, or that one response would be correct for more than one stimulus. Each S received one study trial (first

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1. See Appendix C for instructions to Ss.

presentation of the list) and six learning trials. The Immediate-Recall Control Ss received one recall trial immediately following the sixth learning trial. The recall trial was identical to the learning trial except that the responses were never presented and S did not know if the responses he gave were correct or incorrect. The Immediate-Recall Control Ss were told they would be required to give responses without seeing them before the recall trial was administered.

All Ss returned forty-eight hours after completion of original learning for the second session. Each S was given ten recall trials, again identical to the learning trials except that the responses were not presented. Prior to recall, the Ss were told the responses would not appear and were instructed to give the responses they could. The ten recall trials were followed immediately by a relearning of the lists (identical to original learning) to a criterion of one perfect trial or a maximum of fifteen presentations of the list.

Procedure: Experiment II. In Experiment II, all but the first association Positive and first association Negative Conditions were eliminated. The procedure here was identical to that of Experiment I, with the following exceptions. Immediate-Recall Control Ss were not used in Experiment II; forty Ss were used in each of the two conditions of Experiment II in order to permit the use of the Projection Method in determining the level of original learning. In order to make original learning in both experiments comparable, Ss in Experiment II were given one study trial and five learning trials. This allowed for the estimation (by the Projection Method) of the level of learning on a sixth (hypothetical) trial; in Experiment I, Ss were given six learning trials and the level of original learning on the sixth trial was obtained from the scores of the Immediate-Recall Control Ss. As in Experiment I, Ss in Experiment II received ten recall trials and relearned to a criterion of one perfect

trial or for a maximum of fifteen presentations of the list forty-eight hours after completion of the first session.

Chapter IV

RESULTS

The results of the two experiments will be presented separately. The following abbreviations will be used throughout the remainder of this dissertation: in the Positive Condition, the first association, second association, and Positive List-Control groups will be abbreviated as 1P, 2P and CP, respectively; similarly for the Negative Condition: 1N, 2N and CN. Conditions will always refer to the main Positive (facilitating) and Negative (interfering) conditions. Degree of association will refer to the three levels of stimulus pair relatedness (i.e., first, second and List-Control). In many cases, analysis of the data required combining the original six groups (i.e., 1P, 2P, CP, CN, 2N, 1N) into three groups in the following manner: (1) Combined Positive (1P+2P), (2) Combined Negative (1N+2N), and Combined List-Control (CP+CN).

There are two uses of the word "control": (1) Immediate-Recall Control Ss (Experiment I for determining the level of original learning) and (2) List-Control groups (Experiment I, the third or non-related level of stimulus pair relatedness). There are also two uses of "recall": (1) the ten recall trials which all Ss received forty-eight hours after completion of original learning, and (2), in Experiment I, the one recall trial the Immediate-Recall Control Ss received immediately following completion of original learning.

In Experiment I, the scores obtained from the Immediate-Recall Control

Ss on the single recall trial immediately following original learning are used in the measurement of retention. In all other cases of data analysis, the scores of the Immediate-Recall Control Ss on the six learning trials in each of the six experimental conditions are combined with the six experimental Ss to provide a sufficiently large N.

Results: Experiment I

List differences. Before dealing directly with the main results of Experiment I, possible differences in the difficulty of Lists A and B within each condition should be considered. For these comparisons, the first and second association groups in both the Positive and Negative Conditions were combined to provide a sufficiently large N. This is possible since, as will be reported below, the first and second association groups were not (contrary to predictions) significantly different within conditions. Although the two List-Control groups (i.e., CP and CN) were not significantly different (as predicted), these groups were not combined in this analysis since this would involve comparing lists across conditions; as a result the comparisons of the List-Control groups are made on the basis of N of six. Total number of correct responses during learning (OL) were used as scores. The results of t tests for independent groups are as follows: for the combined Positive group (1P+2P), $t = .3306$, 22 df, $p > .50$; for the combined Negative group (1N+2N), $t = .5679$, 22 df, $p > .50$; for the List-Control Positive group (CP), $t = .2591$, 10 df, $p > .50$; for the List-Control Negative group (CN), $t = 1.9164$, 10 df, $p > .05$. These results indicate that there were no significant differences within conditions in the learning of Lists A and B in Experiment I.

Similar comparisons of List A and List B were made for the ten recall

trials; total number of correct responses during the recall trials were used as scores. The results of these analyses are as follows: 1P+2P, t = .3006, 22 df, p > .50; 1N+2N, t = .4467, 22 df, p > .50; CP, t = 1.1078, 10 df, p > .20; CN, t = .5839, 10 df, p > .50.

T tests using the total number of trials required to relearn to a criterion of one perfect trial as scores were performed to test for list differences in relearning. The results were: 1P+2P, t = .2544, 22 df, p > .50; 1N+2N, t = .8798, 22 df, p > .30; CP, t = .5836, 10 df, p > .50; CN, t = 1.2271, 10 df, p > .20.

The final results indicate that there were no list differences within conditions in the recall and relearning of Lists A and B in Experiment I.

Original learning: Experiment I. Table 2 contains the mean number of correct responses in each of the six experimental groups for (1) the sixth

Table 2

Mean Correct Responses and Mean Trials to Relearn in Experiment I

	Ss	1P	2P	CP	CN	2N	1N
Sixth OL	12	6.50	6.67	4.33	4.96	2.58	2.96
Control-Recall	6	6.83	6.67	5.50	5.75	3.67	3.83
First Recall	12	5.92	5.50	3.83	4.08	2.75	2.25
Trials Relearn	12	2.08	1.75	7.75	6.13	9.08	9.17

(final) learning trial, (2) the Immediate-Recall Control trial, (3) the first recall trial (forty-eight hours later), and (4) the number of trials to relearn to a criterion of one perfect trial. The Immediate-Recall Control means are based on the scores of the six Immediate-Recall Ss in each of the six experi-

mental groups; the means for the sixth OL trial are based on the combined scores of the experimental Ss and the Immediate-Recall Control Ss.

An examination of Table 2 reveals very powerful condition effects in the directions predicted. The increase in the mean of the Immediate-Recall Control scores with respect to the mean for the scores on the final OL trial indicates that original learning (as measured by the one recall trial) actually exceeded the level of learning indicated by the mean number of correct responses on the last learning trial. (See Figure 1, Appendix D.)

To determine the overall effects of conditions and degree of association in OL, an analysis of variance was performed using the number of correct responses during OL as scores. A summary of this analysis is presented in Table 3.

The results of the analysis shown in Table 3 indicate a significant main effect for conditions, and a nonsignificant F for degree of association. The "conditions by degree of association" interaction was significant, however, so the significant simple effects for degree of association in the Positive and in the Negative Conditions are reported at the bottom of Table 3.

Individual comparisons among the six experimental groups were made using Duncan's multiple range test (Steel & Torrie, 1960). The number of correct responses on the final OL trial were used as scores. A complete presentation of these results is found in Appendix E. The findings are summarized below in Table 4.

In Table 4, any two means not underscored by the same line are significantly different (see Appendix E); any two means underscored by the same line are not significantly different.

Examination of Table 4 shows that, as predicted, the first and second association groups of the Positive Condition were learned significantly faster

Table 3

Analysis of Variance of Correct Responses in OL for Experiment I

Source	df	MS	F
Between Ss	71		
A (Conditions)	1	420.0834	38.453***
B (Degree of Association)	2	10.6875	<1.00
AB	2	124.0486	11.3549**
Error (b)	66	10.9247	
Within Ss	360		
C (Trials)	5	119.6722	91.6677**
AC	5	8.7056	6.6684**
BC	10	2.4264	1.8586*
ABC	10	4.4375	3.3991**
Error (3)	330	1.3055	
	Simple Effects		
B for a_1 (Positive)	2	84.8056	7.7627**
B for a_2 (Negative)	2	49.6806	4.5476*
Error (b)	66	10.9247	

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 4

Ranked Means of Six Groups for OL in Experiment I

Group:	2P	1P	CN	CP	2N	1N
Mean:	6.83	6.50	5.58	4.33	3.33	2.58

than the first and second association groups of the Negative Condition. Also, the two List-Control groups did not differ significantly in OL. Contrary to

predictions, there were no significant differences between the first and second association groups within either the Positive or Negative Conditions. Comparisons of List-Control groups with first and second association groups of either condition yielded mixed results.

The results of the comparisons above indicate that the significant simple effects for degree of association obtained in the analysis of variance (Table 3 above) are due primarily to differences between the List-Control group and the first or second association group within each condition, but are not due to differences between first and second association groups within either condition.

Since the first and second association groups within conditions, and the two List-Control groups across conditions, are not significantly different, the groups were combined and the following t tests were made using the number of correct responses on the last OL trial as scores: (1P+2P) > (1N+2N), $t = 8.0012$, 46 df, $p < .001$; (1P+2P) > (CP+CN), $t = 3.3650$, 46 df, $p < .01$; (CP+CN) > (1N+2N), $t = 3.6728$, 46 df, $p < .001$.

In summary, the results presented above indicate that in learning the lists: (1) performance in the first and second association groups in the Positive Condition was significantly superior to the performance in the first and second association groups in the Negative Condition; (2) degree of association was not a significant factor in the learning of the lists; (3) the List-Control groups (CP and CN) performed as predicted, intermediate between the association groups of the Positive and Negative Conditions, and were of approximately equal difficulty.

Retention: Experiment I. The six groups were combined into the 1P+2P, 1N+2N, and CP+CN groups. In each of the combined groups, the mean number of correct responses on the Immediate-Recall control trial was obtained; loss

scores were then obtained for each of the combined groups by subtracting the score of each experimental S on the first of the ten recall trials from the mean of the Immediate-Recall Controls.

In the Positive (1P+2P) Condition, the mean of the Immediate-Recall Control trial was 6.750; the mean number of correct responses on the first recall trial for the experimental Ss was 5.167. The direct-difference method (Underwood et al., 1954, pp. 167-171) indicated that the decrease was not quite significant at the .05 level ($t = 2.1193$, 11 df, $.10 > p > .05$). In the 1N+2N group, the corresponding means were 3.833 (Immediate-Recall) and 2.000 (first recall). This difference was significant ($t = 3.4160$, 11 df, $p < .01$). In the CP+CN group, the respective means were 5.750 and 3.1667; this difference was significant ($t = 3.5558$, 11 df, $p < .01$). With all three groups combined, the overall decrease from the Immediate-Recall Trial (5.444) to the first recall trial (3.444) was significant ($t = 5.1800$, 35 df, $p < .01$).

Significantly greater forgetting was predicted in the Negative Condition as compared to the Positive Conditions. A t test for differential forgetting using the mean number of correct responses on the Immediate-Recall and first recall trials as scores yielded a non-significant t ($t = .2714$, 22 df, $p > .50$).

If the combined Positive and Negative Conditions are compared in terms of the relative amounts retained over the forty-eight hour interval, it is found that 86.5 percent of the material learned was retained in the Positive Condition, whereas only 52.2 percent of the material learned in the Negative Condition was retained. This difference was not significant by an analysis performed after an arcsin transformation of the data: $u = 1.2415$, $p > .10$.

Recall-Trials: Experiment I. An analysis of variance was performed using the number of correct responses during the ten recall trials as scores.

A summary of this analysis is presented in Table 5.

Table 5

Analysis of Variance of Correct Responses in Recall in Experiment I

Source	df	MS	F
Between Ss	71		
A (Conditions)	1	900.035	21.074***
B (Degree of Association)	2	7.038	<1.00
AB	2	259.215	6.070*
Error (b)	66	42.708	
Within Ss	648		
C (Trials)	9	3.022	5.001*
AC	9	.365	<1.00
BC	18	.345	<1.00
ABC	18	.507	<1.00
Error (w)	594	.604	
	Simple Effects		
B for a_1 (Positive)	2	171.108	4.0065*
B for a_2 (Negative)	2	95.145	2.2278
Error (b)	66	42.708	

* $p < .05$ ** $p < .01$ *** $p < .001$

The results of the analysis of variance of the ten recall trials indicate a significant main effect for conditions, and a significant simple effect for degree of association in the Positive Condition, but not in the Negative Condition. The significant effect for trials (C) reflects a gradual increase in the number of correct responses across the ten recall trials (to be discussed below). (See Figure 1, Appendix D.)

Individual comparisons among the six experimental groups were again made with Duncan's multiple range test (Steel & Torrie, 1960), using the number

of correct responses on the first recall trial as scores. A complete presentation of these results is found in Appendix F. The results obtained here are similar to those obtained in the group comparisons for OL, and are summarized in Table 6.

Table 6

Ranked Means of Six Experimental Groups at Recall in Experiment I

Group:	1P	2P	CN	CP	2N	1N
Mean:	5.92	5.50	4.08	3.83	2.75	2.25

In Table 6, any two means not underscored by the same line are significantly different (see Appendix F); any two means underscored by the same line are not significantly different.

As in OL, comparisons among the first and second association groups across conditions yielded significant differences in the predicted directions; also, the two List-Control groups were not significantly different. Comparisons of List-Control groups with first and second association groups of either condition yielded mixed results.

As in original learning, significant differences in the predicted directions were obtained when the six groups were combined into three groups: (1P+2P) > (1N+2N), $t = 5.3713$, $p < .001$; (1P+2P) > (CP+CN), $t = 2.4575$, $p < .05$; (CP+CN) > (1N+2N), $t = 2.4289$, $p < .05$, each with 46 df.

As reported above, there was a significant main effect for Trials (C) in the analysis of variance for recall trials (see Table 4). To examine this effect more closely, combined groups were used and t tests for correlated scores were performed comparing mean correct responses on the first and tenth

recall trials. In the 1P+2P condition, the tenth recall trial mean was significantly higher than the mean for the first recall trial ($t = 2.3633$, df 47, $p > .01$). The same results were obtained in the 1N+2N condition ($t = 2.7194$, df 47, $p < .01$), and in the CP+CN condition ($t = 3.3011$, df 47, $p < .01$).

These findings indicate a significant increase in the number of correct responses over the ten recall trials in each of the combined Positive, Negative, and List-Control groups. The level of correct responding at the end of the ten recall trials did not, in any case, exceed the level of original learning.

A t test for differential increments in the combined Positive and Negative Conditions over the ten recall trials was nonsignificant.

Relearning: Experiment I. The analysis of variance for number of trials to relearn to a criterion of one perfect trial is summarized in Table 7.

The analysis of variance for relearning scores indicates significant condition effects, and significant simple effects for degree of association in both the Positive and Negative Conditions.

Duncan's multiple range test was used to determine differences between the six experimental groups. The number of trials to relearn to a criterion of one perfect trial were used as scores. The results are presented in Appendix G and are summarized in Table 8, which table shows the same pattern of differences for trials to relearn as was found in OL and recall.

Since OL was not to a criterion of one perfect trial, the relearning data were also analyzed with the number of trials required to relearn to the level of original learning as scores. T tests failed to reveal significant differences for the combined groups: (1P+2P)>(1N+2N), $t = .0747$, $p>.50$; (1P+2P)>(CP+CN), $t = 1.7607$, $p>.05$; (CP+CN)>(1N+2N), $t = .9337$, $p>.30$, each with 46 df. All Ss relearned to the level of original learning in one or two trials; this finding is in accord with the finding that retention was high in all groups.

Table 7

Analysis of Variance for Number of Trials to Relearn in Experiment I

Source	df	MS	F
Between Ss	5		
A (Conditions)	1	227.556	14.144**
B (Degree of Association)	2	4.598	<1.00
AB	2	208.430	12.955**
Error (b)	66	16.089	
Simple Effects			
B for a_1 (Positive)	2	133.000	8.267**
B for a_2 (Negative)	2	80.028	4.974**
Error (b)	66	16.089	

* $p < .05$ ** $p < .01$

Table 8

Ranked Means of Six Experimental Groups for Relearning in Experiment I

Group:	1N	2N	CP	CN	1P	2P
Mean:	9.17	9.08	7.75	4.50	2.08	1.75

Error analysis: Experiment I. A direct index of interference in the Negative Condition is provided by comparing the observed number of predicted errors with the number of predicted errors expected by chance. Referring to the diagram of two related stimulus pairs in the 1N group A_1-B_1/ A'_1-C_1, predicted errors are of the type A_1-C or A'_1-B_1, where the response associated with one stimulus is incorrectly elicited by an associatively-related stimulus. Non-predicted errors will refer to all other correctly integrated responses

given in error to a stimulus word. To any stimulus, four (correctly integrated) responses are possible, one is the correct response, and the remaining three are errors. By chance then, those errors referred to as predicted errors will occur one out of three times. Therefore, a comparison of the obtained number of predicted errors with the expected number of predicted errors was possible, and a greater than chance frequency of predicted errors will be interpreted as indicating that pairing different responses with two associatively related stimulus words results in interference in the learning or recall of the lists.

In the analysis of predicted errors, the counting of errors, both predicted and non-predicted, is limited to the first occurrence (in either OL, recall, or relearning) of an error for any particular S-R pairs, since subsequent errors which occur to the same S-R pair in later trials are not independent of the first error.[1] The analysis requires the following values: (1) the number of predicted errors, (2) the number of predicted errors expected by chance (i.e., 1/3), and (3) the number of non-predicted errors. These values were obtained for OL, recall, and relearning combined; a t test based on the obtained values after they had been subjected to an arcsin transformation resulted in a value (u) of 6.3157 standard deviations from the expected mean ($p < .001$). The results of identical separate analyses are as follows: for OL, $u = 3.2836$ ($p < .001$), for recall, $u = 4.3372$ ($p < .001$), and for relearning, $u = 3.5062$ ($p < .001$).

Stage one vs. stage two learning: Experiment I. In order to test for differences between response learning (stage one) and associative learning (stage two) during OL, the following analysis was made. First, the mean number

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1. An error of either type is counted, regardless of the number of correct responses or omissions which occur prior to that error.

of trials required for all responses to be given as properly integrated units--regardless of whether or not they were correctly associated with the proper stimuli--was determined. This provides an index of the trials required to complete stage one learning. In order to determine the completion of stage two learning, the trial on which both responses were given correctly (i.e., both responses must be correctly anticipated on one trial) to the two appropriate (related) stimuli was recorded,[1] and means were calculated.

The mean number of trials required to complete response learning during OL in the 1P+2P, 1N+2N, and CP+CN groups were 2.052, 3.052, and 2.531, respectively.[2] T tests indicated two significant differences between the combined groups in completing stage one learning: (1P+2P) x (1N+2N), $t = 3.386$, $p < .01$; (1P+2P) x (CP+CN), $t = 2.367$, $p < .05$; (CP+CN) x (1N+2N), $t = 1.6539$, $p > .10$, each with 46 df. These results will be considered in the discussion section of this dissertation.

The mean number of trials required to complete associative learning during OL are as follows: 1P+2P, 3.438 trials; 1N+2N, 6.093 trials; CP+CN, 5.063 trials. Comparisons yielded the following results: (1P+2P) x (1N+2N), $t = 7.4889$, 46 df, $p < .001$; (1P+2P) x (CP+CN), $t = 4.6602$, 46 df, $p < .001$; (1N+2N) x (CP+CN), $t = 3.1645$, 46 df, $p < .01$.

T tests were also performed comparing differences between stage one and stage two learning within each of the three combined groups. In each group, associative learning took significantly longer than response learning: (1P+2P), $t = 7.9575$, 23 df, $p < .001$; (1N+2N), $t = 13.5972$, 23 df, $p < .001$; (CP+CN), $t = 14.8557$, 23 df, $p < .001$.

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1. In both stage one and stage two analyses, a score of 7 was assigned if learning was not completed in the six learning trials.

2. See Figure 2, Appendix D.

Comparison of identical S-R pairs: Experiment I. Experiment I was designed to allow comparisons of identical S-R pairs in each condition. The lists were constructed so that equal numbers of identical pairs containing A and A' stimulus words would be available. The tests were performed with the total number of correct responses during OL as scores: the four pairs and the results are presented below; in each case, the pair received significantly more reinforcements when it occurred in the lists of the Positive Condition. TABLE-BIW ($t = 4.5335$, 11 df, $p < .001$); TABLE-RUQ, ($t = 5.4644$, 11 df, $p < .001$); DARK-ZAF ($t = 3.6280$, 11 df, $p < .01$); DARK-GEJ ($t = 5.8234$, 11 df, $p < .01$).

Comparison of A and A' pairs: Experiment I. T tests using total number of correct responses during OL as scores were performed comparing A and A' pairs with combined groups. In the (1P+2P) and (CP+CN), there were no differences between A and A' pairs ($t = .3870$, 23 df, $p > .50$, and $t = 1.844$, 23 df, $p > .10$, respectively). In the (1N+2N) group, A' pairs were learned significantly faster during OL than A pairs ($t = 3.5905$, 23 df, p .01). Similar comparisons of A and A' pairs were made using total number of correct responses during the ten recall trials as scores. The t's for the 1P+2P, 1N+2N, and CP+CN groups were: $t = 1.2037$, $p > .10$; $t = 1.3947$, $p > .10$, and $t = .1071$, $p > .50$, respectively; none of the above is significant with 23 df.

A count of the number of predicted errors which occurred to A and A' pairs during OL in the Negative Condition was made. The number of predicted errors occurring to A pairs was identical to that which occurred to A' pairs.

Results: Experiment II

Experiment I was discontinued when it became apparent that degree of

association was not an effective factor in learning in both the Positive and Negative Conditions. In Experiment II, the second association groups of both conditions were eliminated. Since the List-Control groups had performed as predicted, they were also eliminated. Experiment II consisted of the 1P and 1N groups, with forty Ss in each condition.

In Experiment II, List A was learned significantly faster than List B in the Positive Condition, but not in the Negative Condition. The analyses presented first in this section are concerned primarily with demonstrating significant condition effects beyond the effects of List differences.

List differences. T tests using the total number of correct responses during OL as scores were performed comparing List A and List B within each condition. In the Negative Condition, the difference between lists was not significant ($t = .7470$, 38 df, $p > .40$). In the Positive Condition, however, List A was learned significantly faster than List B ($t = 2.4948$, 38 df, $p < .05$). This difference in the difficulty of the two lists in the Positive Condition means that condition effects are confounded with List effects, and requires a demonstration of significant condition effects independent of, or beyond, any list difference effects.

Original learning: Experiment II. In order to test for condition effects beyond List difference effects, an analysis of variance was performed using the total number of correct responses during OL as scores. Certain features of the experiment complicate this analysis somewhat, and the procedure here deserves comment. First, the study does not contain, as the notation suggests, two lists (A and B) each used twice, but rather contains four different lists: List A in the Positive Condition is not the same list as List A in the Negative Condition, and similarly for List B. This means that Lists is a nested factor under conditions: two lists in the Positive Condition and two

(different) lists in the Negative Condition. In the analysis of variance in which the Lists factor is nested under the conditions factor, it is not possible to evaluate the interaction effect between conditions and Lists (Winer, 1962, pp. 184-191). The second point worth noting in this analysis concerns certain assumptions of the statistical model with regard to the error term used in testing for condition effects. The analysis here will assume that Lists is a random factor; in the present experiment, there are two randomly sampled lists in each condition. In testing for condition effects, the Lists-within-Conditions Mean Square (MS) is used as the error term. Since only two lists were used (i.e., sampled) in each condition, only one comparison between lists is possible in each condition. The F for conditions, therefore, has only 2 df in the denominator; two conditions provide 1 df for the numerator. With only 1 and 2 df, the power of the test is very low: the F required at the .05 significance level is 18.5.

The analysis of variance is presented in Table 9. Total number of correct responses during OL were used as scores.

The analysis of variance presented in Table 9 shows significant trial effects, and a significant conditions by trials interaction effect. The MS for Lists-within-Conditions by Trials was used as the error term for the Within S factors. The F for conditions was not significant ($.10 > p > .05$).[1]

Although the non-significant F for conditions can be interpreted as meaning that the obtained difference between conditions was due to chance variation, the fact that only two degrees of freedom were available for the Lists-Within-Conditions factor warrants considering the possibility that important

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1. The corresponding t value for an F of 15.6893 is 3.9610 ($\sqrt{F}$) which is significant at the .05 level with 2 df in a one-tailed test.

Table 9

Analysis of Variance of Correct Responses in OL for Experiment II

Source	df	MS	F
Between Ss	79		
A (Conditions)	1	597.8025	15.6893
B (Lists Within Conditions)	2	38.1025	
Error (b)	76	9.2859	
Within Ss	320		
C (Trials)	4	128.6313	102.6996**
AC	4	8.0338	6.4142*
BC	8	1.2525	
Error (w)	304	1.3899	

* $p < .05$ ** $p < .01$

condition effects do in fact exist, but are not easily demonstrated. Fortunately, it is possible to evaluate these alternatives. The data presented in Table 9 permit an estimation of the average difference between conditions in terms of the number of correct responses due entirely to conditions effects; that is, due to conditions effects beyond the list difference effects. This estimate is obtained by subtracting the MS for Lists-Within-Conditions (see Table 9) from the MS for conditions. This remaining MS is divided by the number of Ss times the number of lists times the number of trials (nqr). The resulting figure is an estimate of the variance associated with the average difference (in terms of correct responses) between conditions, independent of list effects. This variance estimate is doubled (since there are two means for each condition) and the square root is taken. The results of these calculations in the present analysis were 2.366 responses per S per trial; that is, on the average, there was a difference of 2.366 responses per S per trial in

the two conditions, and this figure does not include differences between conditions due to differences between lists.[1] An average difference of 2.366 responses between conditions can be considered an important or, in the ordinary sense of the word, a "significant" difference; this finding suggests that the failure to obtain a significant F for conditionsin OL (see Table 9) was due to the low number of lists "sampled" in each condition.

A further justification for the conclusion drawn immediately above is found in the calculation of confidence intervals for the difference between the means of the Positive and Negative Conditions. The difference between conditions is 12.2250 responses; using the Lists-Within-Conditions MS and the value of t with 2 df at the .05 level, the values of the confidence interval are 12.2250 ± 13.2715. The interval is very wide, and just includes zero at the extreme lower end, indicating that the null hypothesis cannot be rejected at the .05 significance level.

A further analysis of variance was performed for condition effects in which the scores from Experiment II were combined with the scores from the first five learning trials of the first association Negative group (1N) from Experiment I: the Ss used from Experiment I learned lists identical to those learned in Experiment II. This combined analysis resulted in an F for conditions of 20.275 with 1 and 2 df, $p < .05$. By combining the scores from the two experiments, a significant conditions effect was obtained despite the low power of the test.

The analyses presented above indicate that, as in Experiment I, the experimental manipulations which define the Positive and Negative Conditions in Experiment II were effective in predicting differences in the rate of learn-

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1. The writer is indebted to Dr. D. Burdick of Duke University for this analysis.

ing the lists.[1]

Retention: Experiment II. In Experiment II, the Projection Method (Underwood, 1954) was used to determine the level of learning attained at the completion of OL.[2] This method estimates the number of responses which would be correctly anticipated on a sixth learning trial, which, in turn, would indicate the number of responses correctly recalled from the fifth learning trial. The Projection Method is based upon a successive probability analysis of group data, by means of which the probability of an item being given correctly on some subsequent trial--given that it has received 0, 1, 2 . . . n previous reinforcements, i.e., correct anticipations--can be determined. The probabilities are obtained separately for each experimental condition. To obtain these probabilities, the occurrence or non-occurrence of a correct response on the last (fifth) OL trial is noted, and the number of previous reinforcements occurring to that item during learning are counted, without regard to the trial or trials on which the previous reinforcement(s) occurred. The probability of a response being given correctly on some subsequent trial is obtained by dividing the number of cases in which a correct anticipation occurred on the final (fifth) learning trial following n reinforcements, by the total number of cases in which n reinforcements occurred prior to the final trial. The successive probability analysis, then, permits such statements as: after one reinforcement, the probability of a correct response on some subsequent trial is .67 for any item in the Positive Condition, and .58 for any item in the Negative Condition.

In Experiment II, there were five learning trials in OL. With five

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1. See Figure 3, Appendix D.

2. OL in Experiment II consisted of one study trial and five learning trials.

learning trials, a maximum of five reinforcements is possible during learning, since an item can be learned on the initial study trial and be given correctly on each subsequent trial. The successive probability analysis cannot (directly) provide the probability of a response being given correctly on some subsequent trial given n previous reinforcements when n equals the number of learning trials. In the present study, it is possible to determine the probabilities for 0, 1, 2, 3, and 4 previous reinforcements directly from the data. Determination of the probability of a correct response given five previous reinforcements requires the following procedure. First, the obtained or empirical probabilities are plotted with the number of previous reinforcements along the abscissa and the probability of a correct response along the ordinate. The plotted probabilities roughly describe a negatively-accelerated exponential function, and curves are fitted to these points by the least-squares method (Lewis, 1960, pp. 76-80). The general form of the equation for this curve is:

$$H = (M + d) - M10^{iN},$$

where H is the probability of a correct response, M is the H asymptote, 10 is the base of common logarithms, i is a constant, and N is the number of previous reinforcements. Since it is possible to have a greater than zero probability of a correct response after 0 previous reinforcements (for example, the first correct anticipation can occur on the last learning trial), the additive constant d is included in the equation. When N = 0, H = d; further, when N = 0, and H has some value greater than 0 (and H = d), the H asymptote will be M + d instead of M. Since the successive probability analysis includes values of H greater than 0 when N = 0, and since (as will be presented below), the obtained probabilities rapidly approach one after four reinforcements, the H asymptote (M + d) was set at .99 in both equations. The equations for the Positive and Negative curves for Experiment II are, respectively:

$$H = .990 - .5297\,(10^{-.2312N}),$$

and $$H = .990 - .9419\,(10^{-.3052N}).$$

The equations for the two curves now permit determination of a correct response after five previous reinforcements in each condition: the equations are solved for H when N = 5. Further, the calculated H values for 0, 1, 2, 3 and 4 reinforcements obtained in the curve-fitting procedure are available for use in determining the level of original learning.

Table 10 presents a summary of the procedures described above. The obtained or empirical probabilities from group data for each condition are presented for 0 to 4 reinforcements. The corresponding calculated values are also presented; the latter values include the probability of a correct response given five previous reinforcements.

Table 10

Empirical and Calculated Probabilities of Correct Response Given N Previous Reinforcements

	Number of Previous Reinforcements					
	0	1	2	3	4	5
Positive						
Empirical	.491	.667	.810	.865	.934	
Calculated	.460	.679	.807	.883	.927	.953
Negative						
Empirical	.169	.579	.737	.750	.958	
Calculated	.048	.523	.759	.876	.931	.962

As shown in Table 10, the probability of a correct response given 0 through 3 reinforcements is higher in the Positive Condition than in the Negative; at four previous reinforcements, the curves cross over, although a cor-

rect response is very likely after four and five reinforcements in both conditions. It should be pointed out, however, that the number of cases available for determining the probabilities varied considerably across conditions: in the Positive Condition, there was a large number of cases in which items received four previous reinforcements, and a relatively small number of cases in which items received only 0 or 1 reinforcement. The opposite is true in the Negative Condition, where a large number of cases was available for determining the probabilities for 0 and 1 reinforcement, and a small number of cases in which four correct anticipations occurred during the learning trials (and as Table 10 indicates, in those cases where four reinforcements did occur during learning in the Negative Condition only a very few incorrect anticipations were given on the final trial). The curve-fitting procedure described above did not take into account the variation in numbers of cases available in determining the probabilities.

The calculated values for the probability of a correct response were used in determining the projected OL scores. For each S, the number of reinforcements each item received during OL was noted and the appropriate probability of a subsequent correct response was recorded. When these (eight) probabilities are summed over items for each S, a projected score is obtained which estimates the level of learning attained by that S at the completion of OL. In the Positive Condition, the mean number of correct responses given on the fifth learning trial was 6.350, the projected score for the sixth trial was 6.718. In the Negative Condition, the corresponding values were 3.550 and 3.715, respectively. In both conditions, the level of learning estimated by the Projection Method exceeded the level of learning recorded on the final OL trial. The projected score provides an estimate of the level of learning which includes changes in the level of learning that occurred during the final OL trial.

Loss scores were obtained by subtracting each S's score on the first recall trial from that S's projected OL score. In the Positive Condition, a t test showed a significant decrease over the forty-eight hour retention interval ($t = 4.4979$, 39 df, $p < .001$). In the Negative Condition, a similar comparison also showed significant forgetting ($t = 7.4981$, 39 df, $p < .001$). A t test for differential forgetting in the two conditions was not significant ($t = .7005$, 78 df, $p > .40$). Calculation of the proportions of materials retained showed that in the Positive Condition 80.8 percent of the material learned was retained, whereas in the Negative Condition, 58.5 percent of the material learned was retained. An arcsin transformation of the data and a u-test showed that the relative amount retained in the Positive Condition was significantly greater than that retained in the Negative Condition ($u = 2.1589$, $p < .05$).

In Experiment I, the level of learning after six learning trials was estimated by means of an Immediate-Recall Trial. Since the Projection Method used in Experiment II provides an estimate of the level of learning obtained on a hypothetical sixth learning trial, the two procedures can be compared. In Experiment I, the mean number of correct responses on the Immediate-Recall Trial for the 1P group was 6.83; the projected score for the Positive Condition of Experiment II was 6.73. The mean for the 1N Immediate-Recall Trial (Experiment I) was 3.83; the projected score for the Negative Condition of Experiment II was 3.71. The respective means for the Combined Positive (1P+2P) and Combined Negative (1N+2N) groups of Experiment I were 6.75 and 3.83. The estimates of learning obtained by the two methods are almost identical.

Recall trials: Experiment II. The analysis of the ten recall trials is similar to the analysis of OL in Experiment II. The total number of correct responses during recall were used as scores. T tests revealed that the recall

of List A was significantly superior to that of List B in the Positive Condition ($t = 2.2071$, 38 df, $p < .05$); the lists are not significantly different in the Negative Condition ($t = 1.6865$, 38 df, $p > .05$).

The analysis of variance for recall trials in Experiment II is presented in Table 11. (Also see Figure 3, Appendix D.)

Table 11

Analysis of Variance for Recall Trials in Experiment II

Source	df	MS	F
Between Ss	79	5,285.9950	
A (Conditions)	1	2,339.2800	15.6576[2]
B (Lists Within Conditions)	2	149.4025	
Error (b)	76	34.8409	
Within Ss	720		
C (Trials)	9	3.2050	5.4965**
AC	9	.3967	<1.00
BC	18	.5831	
Error (w)	684	.4820	

** $p < .01$

a. The corresponding t ($\sqrt{F}$) is 3.9569, 2 df, $p < .01$ for a one-tailed test.

Table 11 shows a significant effect for trials, and a nonsignificant effect for the Conditions by Trials Interaction. The F for conditions is below the 18.5 required at the .05 level. Since the Ss in Experiment I received six learning trials whereas the Ss in Experiment II received five learning trials, the data could not be combined as in the case of the analysis of OL. The estimate of the average difference between conditions independent of List differences was 3.309 responses.[1] The confidence interval for the difference be-

1. The procedure used in obtaining this estimate is identical to that de-

tween the condition means at the .05 level is 34.2000 ± 37.1649. Again the confidence interval is very wide, and includes zero at the extreme lower end. Although significant effects for conditions are not demonstrated in the analysis of variance, the analyses above indicate that important condition effects were present throughout recall.

As in Experiment I, a gradual increase in the number of correct responses was observed over the ten recall trials. T tests were performed comparing the mean number of correct responses on the first and tenth recall trials. The increase was significant in both the Positive ($t = 4.050$, 39 df, $p < .001$) and in the Negative ($t = 2.8473$, 39 df, $p < .01$) Conditions. A t test for differential increments in the Positive and Negative Conditions during recall was nonsignificant ($t = .980$, 78 df, $p > .30$). The level of responding at the tenth recall trial did not exceed the level of responding attained during OL in either condition.

Relearning: Experiment II. T tests using the number of trials to relearn to a criterion of one perfect trial as scores were performed comparing Lists A and B within conditions. In both the Positive and Negative Conditions, the results indicated no significant List differences in relearning: for the Positive Condition $t = 1.9925$, 38 df, $p > .10$; in the Negative Condition $t = 1.6301$, 38 df, $p > .10$.

The number of trials required to relearn to a criterion of one errorless trial in the Positive Condition was 2.475, and in the Negative Condition 10.500. This difference was significant ($t = 10.7704$, 78 df, $p < .001$). A comparison of the Positive and Negative Conditions using the number of trials to relearn to the level of original learning also yielded a significant difference ($t =$

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scribed above in the analysis of OL in Experiment II.

2.3545, 78 df, $p < .05$).

Error analysis: Experiment II. An analysis of predicted errors was made in the Negative Condition of Experiment II identical to that reported above in Experiment I. For OL, recall, and relearning taken together, the total number of first-wrong predicted errors was 227, for non-predicted errors 240, yielding a total of 467 first errors. An arcsin transformation of the data and a significance test of the obtained u-value revealed that the number of predicted errors had exceeded chance expectation (one-third) by 6.899 S.D.s ($p < .0001$). Separate analyses revealed significantly greater than chance numbers of predicted errors in OL and in relearning: the u-values were 4.3526 ($p < .0005$) and 5.7395 ($p < .0001$), respectively. A nonsignificant value was obtained in the analysis of the recall scores ($u = 1.2212$, $p > .10$).

Stage One vs. Stage Two learning: Experiment II. The analysis presented here is identical to the stage analysis presented in Experiment I. The mean number of trials required for all responses to be given as an integrated unit at least once (regardless of stimulus pairing) was determined for the Positive (2.1688) and for the Negative (2.8250) Conditions.[1] This difference was significant ($t = 3.3125$, 78 df, $p < .01$), suggesting that Stage One learning was faster in the Positive Condition. The mean number of trials required for each pair of (different) responses to be given correctly to their proper stimuli (in one trial for each pair) was determined for the Positive (3.2563) and for the Negative (5.0875) Conditions. This difference was also significant ($t = 7.7230$, 78 df, $p < .001$), indicating that Stage Two learning was significantly faster in the Positive Condition. A t test for differences between Stage One and Stage Two learning in the Positive Condition yielded a

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1. See Figure 4, Appendix D.

significant t ($t = 9.8061$, 39 df, $p < .001$), as did a similar comparison in the Negative Condition ($t = 17.2774$, 39 df, $p < .001$). By definition, Stage Two learning requires an equal or greater number of trials than Stage One learning.

Comparison of identical S-R pairs: Experiment II. A comparison of eight S-R pairs which occurred in both the Positive and Negative Conditions resulted in significantly faster learning in the Positive Condition for all but two of the pairs.[1] In the two pairs that were not significantly different across conditions, i.e., QUEEN--RUQ and NAIL--ZAF, the differences were in the predicted direction. The S-R pairs from each condition were ranked according to the mean number of correct responses given during OL. These rankings showed that the pair QUEEN--RUQ was learned fastest in both the Positive and Negative Conditions, indicating that this item was particularly easy to learn. The pair NAIL--ZAF was relatively low in the ranks of the Positive Condition (tenth out of sixteen), and relatively high in the Negative Condition (fifth out of sixteen). As noted above, however, in both cases the items received more reinforcements when they appeared in the lists of the Positive Condition.

Comparison of A and A' pairs: Experiment II. T tests were made comparing A and A' pairs within conditions using the total number of correct responses during OL as scores. In the Positive Condition, a t test revealed no difference in the learning of A and A' pairs ($t = 1.0770$, 39 df, $p > .20$). In the Negative Condition, significantly more correct responses were given to A' pairs than to A pairs ($t = 4.0627$, 39 df, $p < .001$); identical results were obtained in Experiment I. Since this finding is in agreement with the predic-

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1. The procedure here was identical to the analysis performed in Experiment I. Total numbers of correct responses during OL were used as scores. The results of this analysis are presented in Appendix H.

tions of mediated interference which follow from the directionality of the association between stimulus pairs (i.e., the tendency for A to elicit A' is greater than the tendency for A' to elicit A) a further analysis was performed comparing the number of predicted errors occuring to A and A' pairs during OL. Since the number of predicted errors is not independent of the number of correct responses, the finding is only tentative, and the significance level reported is not exact. The results of the t test did show that in the Negative Condition more predicted errors occurred to A pairs than to A' pairs during OL ($t = 2.1563$, 39 df, $p < .05$). Comparisons were also made using the total number of correct responses during recall as scores; the Positive Condition showed no difference in the recall of A and A' pairs ($t = .3960$, 39 df, $p > .50$). In the Negative Condition, significantly more correct responses were given to A' pairs than to A pairs during recall ($t = 4.1567$, 39 df, $p < .001$).

Chapter V

DISCUSSION

Before dealing directly with the major findings of the present study, a comment regarding the methods used in determining the level of original learning is in order. The two methods employed here for this purpose are very different in nature: the Immediate-Recall method used in Experiment I determines the level of learning attained directly from one recall trial administered to control Ss; the method of Projection used in Experiment II estimates the level of learning attained on a hypothetical next trial by means of a successive probability analysis of group data. Although both methods are costly in terms of the number of Ss required, the fact that the two methods resulted in almost identical scores in the two experiments speaks very favorably for their utility and accuracy in the study of retention.

The major findings of the present study will be summarized and discussed under separate headings.

Learning

In Experiment I, facilitating and interfering effects were demonstrated in the learning of A-B/A'-B and A-B/A'-C lists, respectively. Significant simple effects were found for the Degree of Association factor in both the Positive and Negative Conditions. Significance tests failed to reveal significant

differences between the first and second association groups within either condition; the only significant differences among groups within conditions were those between the List-Control group and either of the association (i.e., first or second) groups. Although these latter differences were not significant in every case, the differences were invariably in the predicted direction. Comparisons between either of the Positive association groups (1P or 2P) and either of the Negative association groups (1N or 2N) were always significant and in the predicted direction. Comparisons of the Combined groups (1P+2P, 1N+2N, and CP+CN) revealed that both the Combined Positive group and the Combined Negative group were significantly different (in the predicted directions) from the Combined List-Control groups. These findings indicate that absolute intra-list transfer effects were obtained in both the positive and negative directions.

Significant list-differences in the Positive Condition of Experiment II obscured main condition effects. Subsequent analyses indicated that the failure to obtain a significant F for conditions was due to the low power of the test, resulting from the fact that only two lists were sampled in each condition. A significant F for conditions was obtained when the appropriate scores from Experiment I were included in the analysis of variance.

The effectiveness of the experimental conditions in predicting the rate of learning was further confirmed by the finding that (with two exceptions in Experiment II) particular S-R pairs appearing in the lists of the Positive Conditions were learned significantly faster than identical S-R pairs in the lists of the Negative Conditions. Although the List effect observed in the Positive Condition of Experiment II indicates that certain fortuitous associations between stimulus and response terms probably contributed to the production of facilitation, the fact that significant differences were obtained between those

pairs which did appear in both conditions indicates that the observed effects were due primarily to experimental manipulations.

The predictions that the associative relation between stimulus pairs would contribute significantly to the production of interference was confirmed by the analysis of predicted errors in the Negative Conditions. Although this analysis does not directly confirm the hypothesis that the interference was "mediated," the greater than chance occurrence of predicted errors is, of course, in line with the hypotheses that mediated interference occurred on the basis of associatively-related stimulus pairs in the Negative Conditions.

Degree of Association (excluding the List-Control level) in Experiment I was not an effective factor in the learning of the lists, even though a relatively steep gradient of associative-relatedness was used. Second associates (A'_2) were as effective as first associates (A'_1) in the production of both facilitation and interference. This finding indicates that under the conditions of the present study, associative norms are not critical in predicting facilitating and interfering effects.

Retention

Those processes responsible for facilitation and interference in the learning of the lists did not affect the retention or recall of the lists, with the exception of significantly greater forgetting in the Negative Condition of Experiment II when the relative amounts of materials retained were compared. Retention was high in all conditions of both experiments. On the average, Ss in the Positive Conditions of both experiments learned approximately 6.7 responses and recalled 5.5, whereas Ss in the Negative Conditions learned only 3.7 responses (just below the total number of different responses

in the lists) and recalled 2.1. Differential forgetting might have resulted if Ss had been permitted or required to learn more responses.

Relearning to the level of original learning was accomplished in one or two trials by all Ss, although in Experiment II relearning to the level of original learning was significantly faster in the Positive Condition than in the Negative Condition.

There were significant increases in the number of correct responses across the ten recall trials in all conditions of both experiments. Similar findings have been reported by Richardson (1958) and by Goss, Morgan and Golin (1959). Richardson, who found that the level of responding after five recall trials exceeded the level of original learning in three of nine experimental conditions, describes this increase over recall as similar to a warm-up effect. In the present study, the level of correct responding at the end of the ten recall trials never exceeded the level of original learning. Whatever factors are responsible for this increase are apparently independent of the major experimental variables of the present study, since comparable increases were observed for all groups.

Stage One vs. Stage Two

The results of the stage analysis are somewhat ambiguous. It was predicted that the number of trials required to complete response-learning would be roughly equal in the Positive and Negative Conditions; however, the Negative Conditions required a significantly greater number of trials to complete response-learning in both experiments. Although it is possible that response-learning was generally impaired in the Negative Condition through competition from the response or response-components paired with related stimuli, the sig-

nificant differences in response-learning between conditions was probably due to the fact that Ss in the Negative Conditions were relucant to give a response--even though the response itself was learned--before being relatively certain of the proper stimulus.

The available data do suggest, however, that the observed effects were due primarily (if not totally) to facilitation and interference in the second or associative stage of learning. Averaging the mean trials for both experiments shows that response-learning was completed in 2.61 and 2.94 trials in the Positive and Negative Conditions, respectively. Associative learning was completed in 3.35 trials in the Positive Conditions, but not until 5.59 trials in the Negative Conditions. The Positive and Negative Conditions are relatively close in terms of the trials required to complete response-learning. However, associative learning was completed in about three-fourths of a trial after response-learning in the Positive Conditions, whereas associative learning was not completed until the very end of OL in the Negative Conditions. These considerations suggest that the locus of facilitation and interference in the present study lies primarily in the second or associative stage of learning; this interpretation is in agreement with the findings of McGehee and Schulz (1961) reported above.

A vs. A' Pairs

The failure to find differences in the learning of A and A' pairs in the Positive Conditions of both experiments is interpreted as indicating that the direction of the associative connection between stimulus pairs was not a critical factor in the production of facilitation. That is, the fact that the tendency for A to elicit A' is greater than the tendency for A' to elicit A

is not crucial in the learning of a list in which pairs of related stimuli are associated with identical responses. This finding is in agreement with Storms's (1958) report of bidirectionality with normatively unidirectional materials in a one-stage mediation experiment.

In the Negative Conditions of both experiments, the A' pairs were learned significantly faster than the A pairs, and predicted errors occurred significantly more often to A pairs than to A' pairs during OL in Experiment II. This finding can be interpreted to mean that the direction of the association between stimulus pairs is critical in the production of interference. This follows from the fact that, as mentioned above, the main stimulus word A would elicit as a (implicit) response the stimulus word A' and its associated response--now present to compete with the correct response to A--more frequently than A' would elicit A and its associated response. The result here would be greater interference in the learning of A pairs, as was observed in the Negative Conditions of both experiments.

Mediation

The major hypothesis of the present study states that the facilitating and interfering effects observed in the learning of A-B/A'-B and A-B/A'-C lists are mediated effects. Stimulus-generalization provides an alternative explanation of the effects, and should be discussed here in evaluating the mediation hypothesis. The mediational-linking hypothesis has been discussed in earlier sections of this dissertation; with regard to the stimulus-generalization hypothesis, the line of reasoning here is similar to that presented above in the discussion of the response-generalization interpretation of positive retroaction and transfer. Facilitation via stimulus-generalization would be

predicted in the Positive Conditions of the present study as a result of (mutual) generalized reinforcement occurring between A-B and A'-B pairs during learning. Interference in the Negative Conditions would result from generalized reinforcement occurring from A-B to A', resulting in some associative strength between A' and B: the response B would now be present to compete with the correct response (C) to stimulus A'. The same process would occur in the reverse direction from A'-C to A. Predicted errors would be expected in the Negative Condition on the basis of stimulus-generalization. Although the present study was not specifically designed to test alternative hypotheses of intra-list transfer, certain findings are relevant to this issue and permit some general evaluation of the two hypotheses.

First, with regard to the factor of directionality, the failure to find significant differences in the learning of A and A' pairs in the Positive Conditions of both experiments lends some support to the stimulus-generalization hypothesis. The generalization hypothesis states that (mutual) generalized reinforcement would occur between A-B and A'-B pairs during learning and produce facilitation relative to the Positive List-Control groups. Since similarity is a symmetrical relation,[1] there is no apparent reason to expect differences in the rate or effectiveness of generalized reinforcement occurring between A-B and A'-B pairs. The finding of significant differences in the learning of A and A' pairs in the Negative Conditions supports the mediational-linking hypothesis, and raises questions regarding the generalization theory, since there is no reason why generalized interference should occur differentially in the learning of A-B and A'-C pairs.

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1. There is no direction in the similarity relation: if A and A' are similar, then A is as similar to A' as A' is similar to A. This is usually not the case with free-associates, i.e., free-associates are directional.

The Degree of Association factor is difficult to interpret from the generalization point of view. The fact that second associates were as effective as first associates in the production of both facilitation and interference is contrary to the predictions which follow from the mediational-linking hypothesis. However, to interpret this finding in terms of the stimulus-generalization hypothesis would require some judgment regarding differences in the degree of similarity between the pairs A and A'_1, and A and A'_2. If Haagen's (1949) report of a .90 correlation between associativeness and similarity is applicable to free associates, the generalization theorist would have to explain why equal amounts of generalized reinforcement occurred to stimulus pairs of different degrees of similarity.

In summary, the results of the present study indicate that both the mediational-linking and stimulus-generalization hypotheses are unsatisfactory: the generalization hypothesis is supported by the finding that no differences exist between A and A' pairs in the Positive Conditions, but is refuted by the finding that A' pairs were learned significantly faster than A pairs in the Negative Conditions. This latter finding supports the mediational-chain hypothesis, although the mediation hypothesis is brought into question by the finding that Degree of Association was not an effective factor in the production of facilitation or interference. Finally, the findings regarding the learning of A and A' pairs suggest the possibility that the process or mechanism underlying intra-list facilitation may be different from that underlying intra-list interference.[1]

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1. Up to this point the discussion of underlying mechanisms has approached the problem assuming that the most straightforward explanation of the results would involve one or the other of the two processes working in both the positive and negative directions.

The Positive Conditions of the present study were designed to be analogous to the positive retroaction situation. In the A-B, A-B' paradigm, mediational chains of the type A-B-B' are assumed to be responsible for retroactive facilitation and positive inter-list transfer. Mandler (1954) has proposed an alternative explanation of inter-list facilitation in paired-associate learning. Mandler compares the A-B, A-B' paradigm to the concept-formation situation and applies his notion of symbolic responses to explain the facilitation. The responses B and B' both elicit a common symbolic response, i.e., an analogue or implicit representation of the overt verbal response. During List 1 learning, the common symbolic response elicited by, or accompanying, response B is also associated with the stimulus A. In List 2 learning, the acquisition of A-B' is mediated by the symbolic response to B, now elicited by both stimulus A and response B', resulting in facilitation of List 2 learning and enhanced recall of List 1. This explanation differs from the mediational-linking hypothesis in that the mediating element is not a "chain" of associated or similar words (A-B-B'), but is rather a common (symbolic) response elicited by both B and B'.[1]

In the Positive Conditions of the present study, the S is required to learn one response to two (associatively related) stimuli. This procedure is comparable to the concept-formation situation, and it is reasonable, therefore, to entertain the hypothesis that in learning the A-B/A'-B lists, facilitation occurs on the basis of the formation of a common concept or response, which mediates the association between each of the two stimuli and the response. This hypothesis will be referred to as the common-concept hypothesis, and can

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1. The symbolic response is assumed to represent the common or shared meaning which provides the basis of the similarity between B and B'.

be viewed as an application of Mandler's (1954) inter-list formulation to the intra-list situation. The common-concept hypothesis states that facilitation occurs as a result of the formation of a common concept, elicited by both A and A', which mediates the association with response B.

Direct support for the common-concept hypothesis is reported by Richardson (1960) in a study investigating similarities between concept-learning and rote-learning tasks. Richardson used four lists of sixteen paired-associates arranged so that four groups of four stimulus terms with known intra-stimulus relationships were paired with the same response. The four lists differed in terms of the nature of the relationship existing among each group of four stimuli. The relationships were: (1) low similarity, (2) high similarity, (3) dominance concepts, and (4) class concepts. The latter two lists (3 and 4) were constructed so that the four stimulus terms in each group elicited a single common response; in list 3, the dominance concepts were obtained from Underwood and Richardson (1956), and the class concepts of list 4 were obtained from Reed (1946). The lists were also rated by student judges for the degree of association existing among each group of stimulus terms. Comparison of rates of learning showed that the list in which the group of stimulus terms elicited a common class-concept was learned faster than any of the other three lists. The speed of learning, or amount of intra-list transfer, was not predicted by ratings of associativeness: the class concept list was rated second in terms of associativeness. Richardson concludes that part of the transfer between stimuli with the same response was based on a common mediating response, e.g., a class-name.

Kaplan (1959) has demonstrated inter-list facilitation in paired-associate learning with pre-experimentally formed conceptual relationships. Two training lists and a test list were employed in a mediation paradigm:

B-A, C-A, and B-C. The A response in the two training lists is the concept name elicited by both B and C (the stimuli of the two training lists). Kaplan was unable to demonstrate positive transfer when the B-A and C-A training list associations were experimentally acquired.

The common-concept hypothesis will now be discussed in relation to the present study, and it will be shown that this hypothesis--in conjunction with one or two assumptions--provides the most satisfactory account of intra-list facilitation. In general, the common-concept hypothesis states that the acquisition of response B to stimuli A and A' is mediated by a common concept elicited by both A and A', and that the formation of this common concept produces facilitation in the learning of the lists.

With regard to the first association Positive list (1P), it can be assumed that the presentation of the stimulus word KING elicits a number of associated or related words and concepts, such as "queen," "crown," "George," "royalty," etc. The stimulus word QUEEN also elicits a number of associates, such as "king," "Elizabeth," "royalty," etc. The class concept royalty, common to both KING and QUEEN, is elicited by both stimuli prior to any experimental learning; in this example, it will be assumed that royalty is the common concept which acts as a mediator. The common concept is formed or developed as a mediator during learning when the stimulus-response relationships are perceived, or, during the process of associating KING and QUEEN with the same response.[1] For each pair of stimulus terms, a common concept is formed, which mediates the association with the proper response. This process might be

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1. This process might involve differential reinforcement of the various associates elicited by each stimulus; that association which is common to both stimuli, i.e., the common concept, would presumably receive greater reinforcement.

viewed as the reduction of an eight-pair list to a four-pair list: four concepts or mediators, and four responses, which would have facilitating results.[1] With regard to the findings of the present study, the hypothesis that facilitation occurs via the formation of a common concept is in accord with the finding that no differences existed between A and A' pairs in the Positive Conditions, since the common concept is as effective for stimulus words of the type A as for those of the type A' when both stimuli are paired with the same response.

With regard to the failure of Degree of Association to predict the relative amounts of transfer, the following considerations are relevant. In the 1P list, it was assumed that KING and QUEEN both elicit royalty, a common mediating response. Similarly, TABLE and CHAIR both elicit the concept furniture. In the 2P list the pair KING and CROWN might also elicit the class concept royalty. Here it is assumed that the pair KING and CROWN elicit royalty as readily or as easily as the pair KING and QUEEN; that is, second associates can elicit mediating concepts as readily as first associates. Further, the common concept functions as a mediator as effectively for the second associates as for first associates. Also with regard to the 2P list, TABLE and FOOD might elicit the common concept eating. Here it is assumed that TABLE and FOOD elicit eating as readily as TABLE and CHAIR elicit furniture, and that both mediators are equally effective. These considerations would account for the finding that the second associates were as effective as first associates in producing facilitation.

In the Positive List-Control group (CP), the stimulus words paired with the same response do not provide suitable conditions for the formation of

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1. This conception is in accord with the notion that concepts provide a necessary economy in cognitive functioning by rendering similar stimuli equivalent in terms of response evocation.

a common mediating concept: TABLE and PATH, HAMMER and GLOBE, etc., do not readily permit the formation of a common concept. The result is that the association lists (1P and 2P) are learned much faster than the CP list.

The common-concept hypothesis, then, provides an adequate account of the major findings in the Positive Conditions of the present study. This hypothesis explicitly involves mediation, but differs from the mediational-linking hypothesis in that the mediator is a common concept, or some common response-process elicited by both stimuli. The common concept may be any type of response-process which involves that common element which provides the basis for the similarity or associativeness of the stimulus pairs, e.g., the class or category which includes both stimuli. The mediational-linking hypothesis, on the other hand, assumes that mediation occurs via "chains" of similar or associated words, e.g., A-B-B', or A-A'-B.

In the Negative Conditions of the present study, the S is required to learn different responses to pairs of associated stimuli. Here the procedure is not comparable to the concept-formation situation. The finding that A' pairs were learned faster than A pairs in the Negative Conditions supports the hypothesis that some of the negative transfer observed resulted from mediational chains of the type A-A'-B or A'-A-C. The mediational linking hypothesis is the most adequate explanation of the results obtained here. Although the 2N group was consistently higher in terms of number of correct responses than the 1N group, the difference between the two groups was not significant. However, in view of the findings regarding A and A' pairs, and the results of the analysis of predicted errors, the mediational-chain hypothesis appears to be the most acceptable hypothesis of intra-list interference.

In summary, it is concluded that mediation is the basic mechanism underlying intra-list facilitation and interference in the present study. However,

the mediational processes underlying facilitation are thought to be different from those underlying interference. In the Negative Conditions, the mediational-linking hypothesis provides an adequate explanation of the results. In the Positive Conditions, the mediating process is thought to be a common concept, elicited by both of the related stimuli, which mediates the learning of the response.

Chapter VI

SUMMARY

Two experiments were conducted to demonstrate mediated facilitation and interference in the learning and retention of single lists of paired associates under conditions analogous to the positive and negative retroaction paradigms. In Experiment I, eight-pair lists were constructed with free-association words as stimuli and four nonsense-syllable responses (each used twice). Pairs of stimulus words with known degrees of associative-relatedness were associated with identical (Positive Condition) or different (Negative Condition) responses. Lists with three degrees of associative-relatedness were used: first associates, second associates, and a non-related or control list. Subjects received standard anticipation learning instructions and were given six learning trials. Subjects returned forty-eight hours later and were administered ten recall trials and when relearned the list to a criterion of one errorless trial.

Positive and negative intra-list transfer was demonstrated in the learning of the lists of Experiment I. Degree of Association was not an effective factor in the production of facilitation or interference; the List-Control groups performed as predicted midway between the Positive and Negative association groups.

In Experiment II, the second association and List-Control groups of both conditions were eliminated, and the experiment was repeated using only

the first association Positive and first association Negative groups.

The results of both experiments indicate that considerable intra-list facilitation and interference was produced in learning the A-B/A'-B and A-B/A'-C lists, respectively. Retention was not affected by the experimental manipulation and was consistently high in all groups. Alternative hypotheses regarding the mechanisms underlying the observed effects were discussed, and it was concluded that the mediational-linking hypothesis provides the most adequate explanation of intra-list interference, and that the common-concept hypothesis provides a satisfactory explanation of intra-list facilitation in the present study.

The two experiments permitted a comparison of two methods of estimating the level of original learning. The Immediate-Recall Method and the Projection Method resulted in almost identical scores in the two experiments.

APPENDIXES

Appendix A

ABBREVIATIONS

OL: Original (or first-list) Learning

IL: Interpolated (or second-list) Learning

PI: Proactive Inhibition

RI: Retroactive Inhibition

MFR: Modified Free Recall

MMFR: Modified, Modified Free Recall

M.S.: Mean Square

S: Subject

1P: First Association Positive

2P: Second Association Positive

CP: List-Control Positive

CN: List-Control Negative

2N: Second Association Negative

1N: First Association Negative

Appendix B

LISTS

First Association

Stimuli	Responses[1]			
	List A		List B	
	+	-	+	-
TABLE	BIW	BIW	RUQ	RUQ
CHAIR	BIW	GEJ	RUQ	ZAF
HAMMER	GEJ	RUQ	ZAF	BIW
NAIL	GEJ	ZAF	ZAF	GEJ
DARK	ZAF	GEJ	GEJ	ZAF
LIGHT	ZAF	RUQ	GEJ	BIW
KING	RUQ	ZAF	BIW	GEJ
QUEEN	RUQ	BIW	BIW	RUQ

Second Association

TABLE	BIW	BIW	RUQ	RUQ
FOOD	BIW	GEJ	RUQ	ZAF
HAMMER	GEJ	RUQ	ZAF	BIW
SAW	GEJ	ZAF	ZAF	GEJ
DARK	ZAF	GEJ	GEJ	ZAF

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1. For lists A and B, GEJ and ZAF, and RUQ and BIW were interchanged.

Stimuli	Responses			
	List A		List B	
	+	-	+	1
NIGHT	ZAF	RUQ	GEJ	BIW
KING	RUQ	ZAF	BIW	GEJ
CROWN	RUQ	BIW	BIW	RUQ
List-Control				
TABLE	BIW	BIW	RUQ	RUQ
PATH	BIW	GEJ	RUQ	ZAF
HAMMER	GEJ	RUQ	ZAF	BIW
GLOBE	GEJ	ZAF	ZAF	GEJ
DARK	ZAF	GEJ	GEJ	ZAF
PAPER	ZAF	RUQ	GEJ	BIW
KING	RUQ	ZAF	BIW	GEJ
SHELL	RUQ	BIW	BIW	RUQ

Appendix C

INSTRUCTIONS FOR SUBJECTS

The following instructions were given to every S at the beginning of the first learning session:

"This is an experiment in learning certain verbal materials. The material will be presented to you in the aperture of this machine. When I start the machine, an ordinary English word will appear in the left-hand column of the aperture, and will remain there for a short interval. The words that appear in the left-hand column are stimulus words which will serve as cues for you to give the response you will be learning. When the machine starts the second time, the same stimulus word will appear again in the left-hand column, and the response term that is always paired with it will appear in the right-hand column. Your task is to learn the response so that you can give it when the stimulus word is first presented alone. The response terms are three letter nonsense syllables; rather than trying to pronounce them, spell them aloud so that I can hear each letter. There are a certain number of these stimulus-response pairs which comprise a list. A list contains each pair once, and each time you complete the list, asterisks will appear in the aperture. Although the same stimulus-response pairs will always be presented, the pairs themselves are in different orders in different lists, so you cannot just learn the responses in order, you have to learn which response goes with which stimulus.

"Give a response as soon as you know it, and give it every time its

stimulus word appears. Be sure to give the response before it appears in the aperture. Guessing is permitted. Continue giving responses until I stop the machine. Try to learn as many responses as quickly as you can.

"Any questions?"

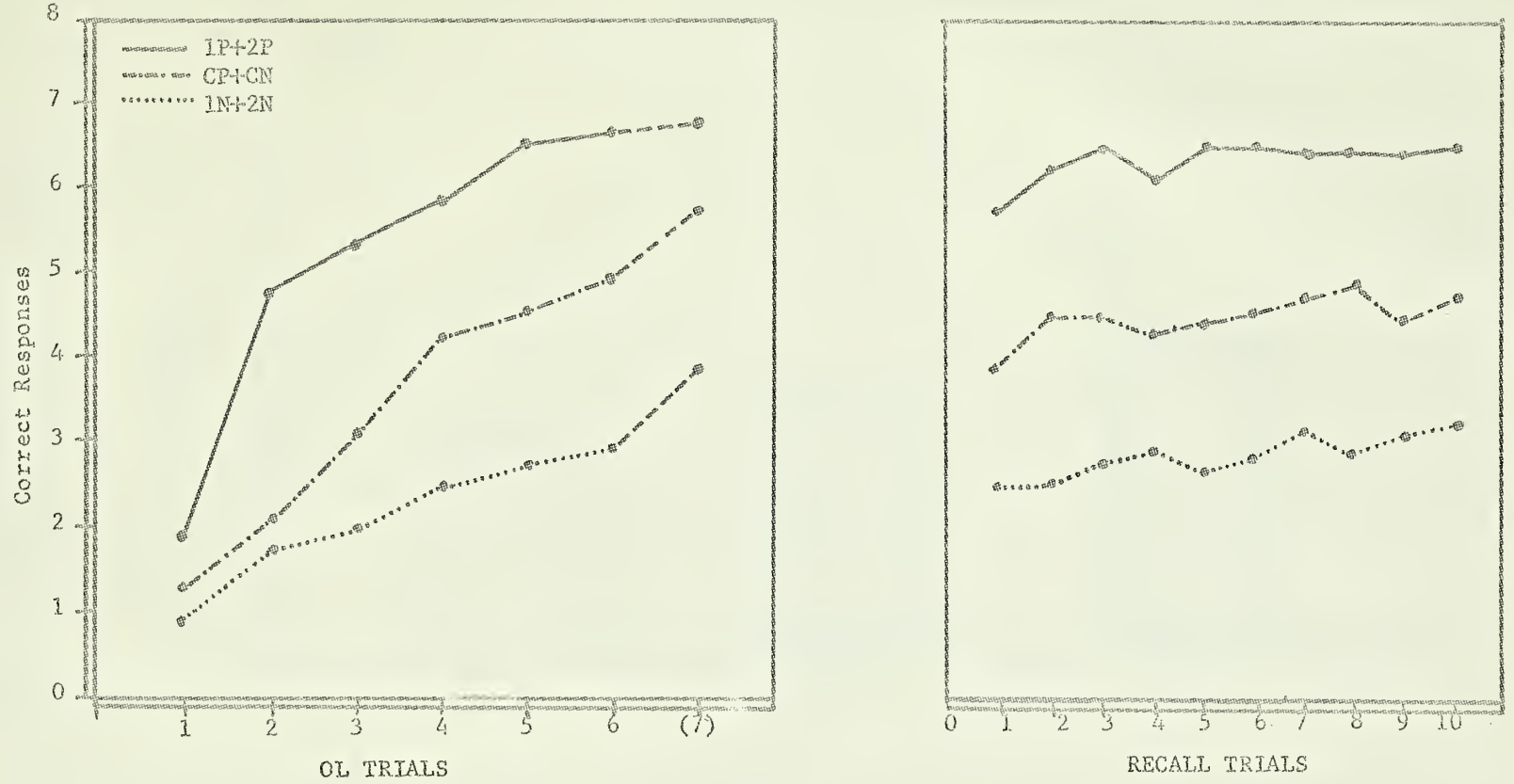

Figure 1. Experiment I. Mean Number of Correct Responses for OL and Recall - Combined Groups.

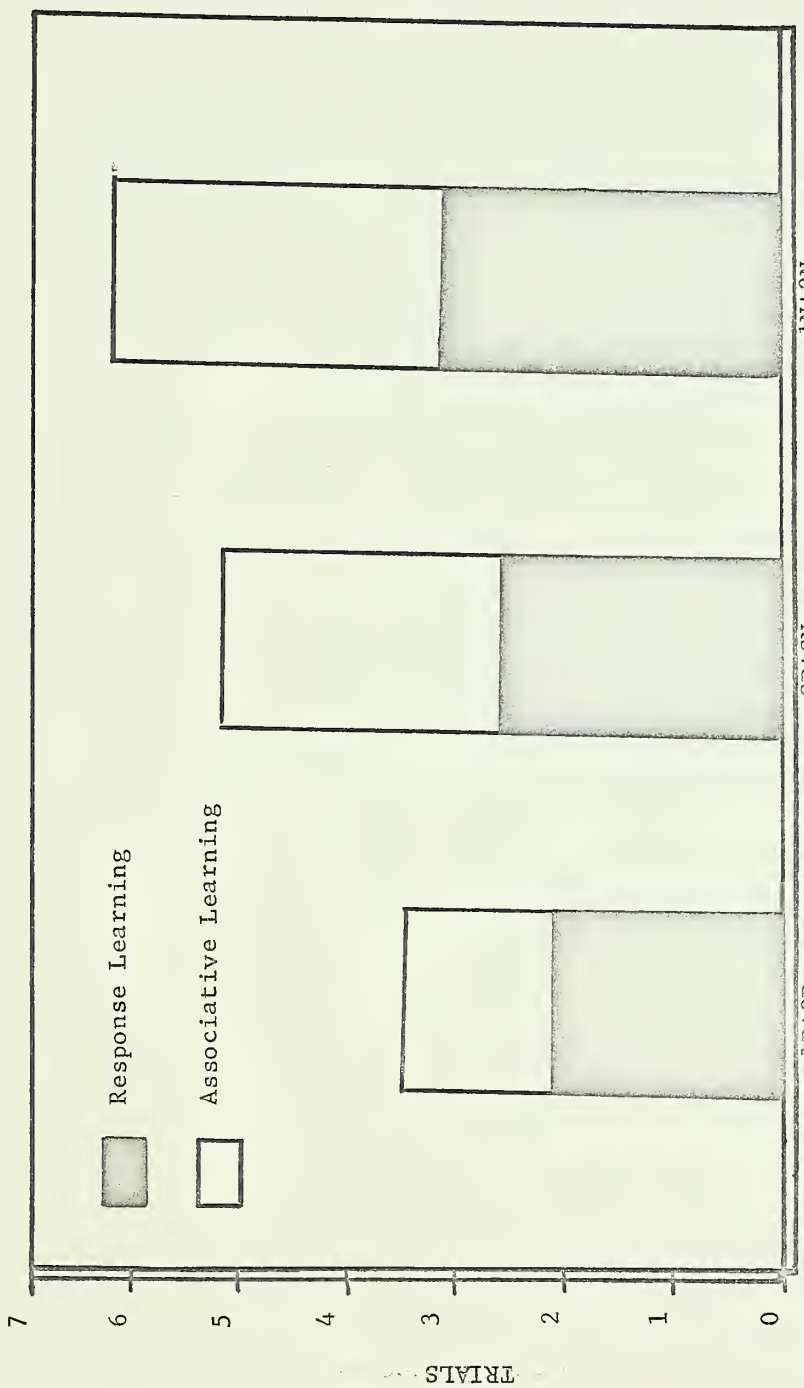

Figure 2. Experiment I. Mean Number of Trials Required to Complete Stages One and Two during OL - Combined Groups.

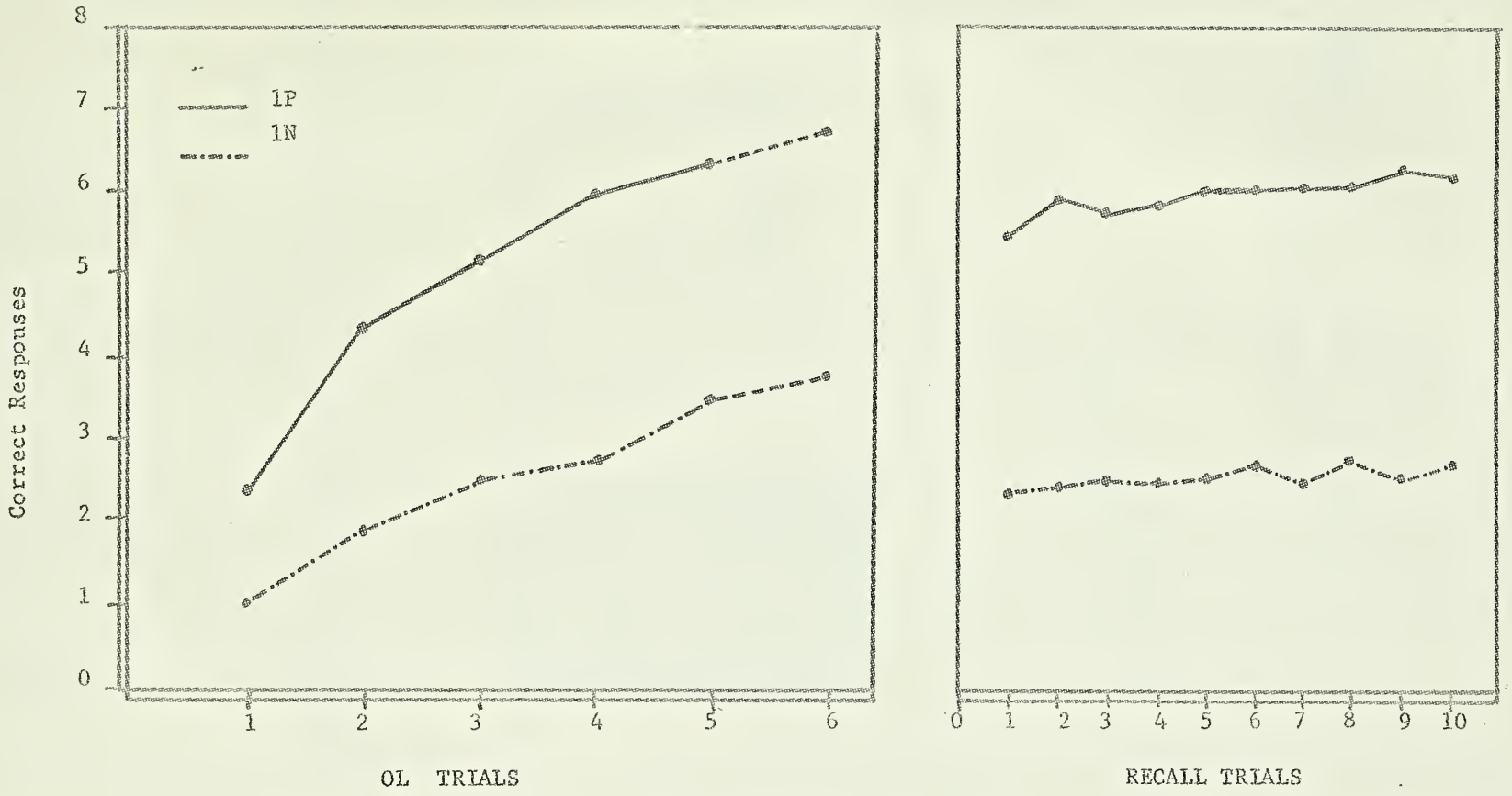

Figure 3. Experiment II. Mean Number of Correct Responses for OL and Recall - Positive and Negative Conditions.

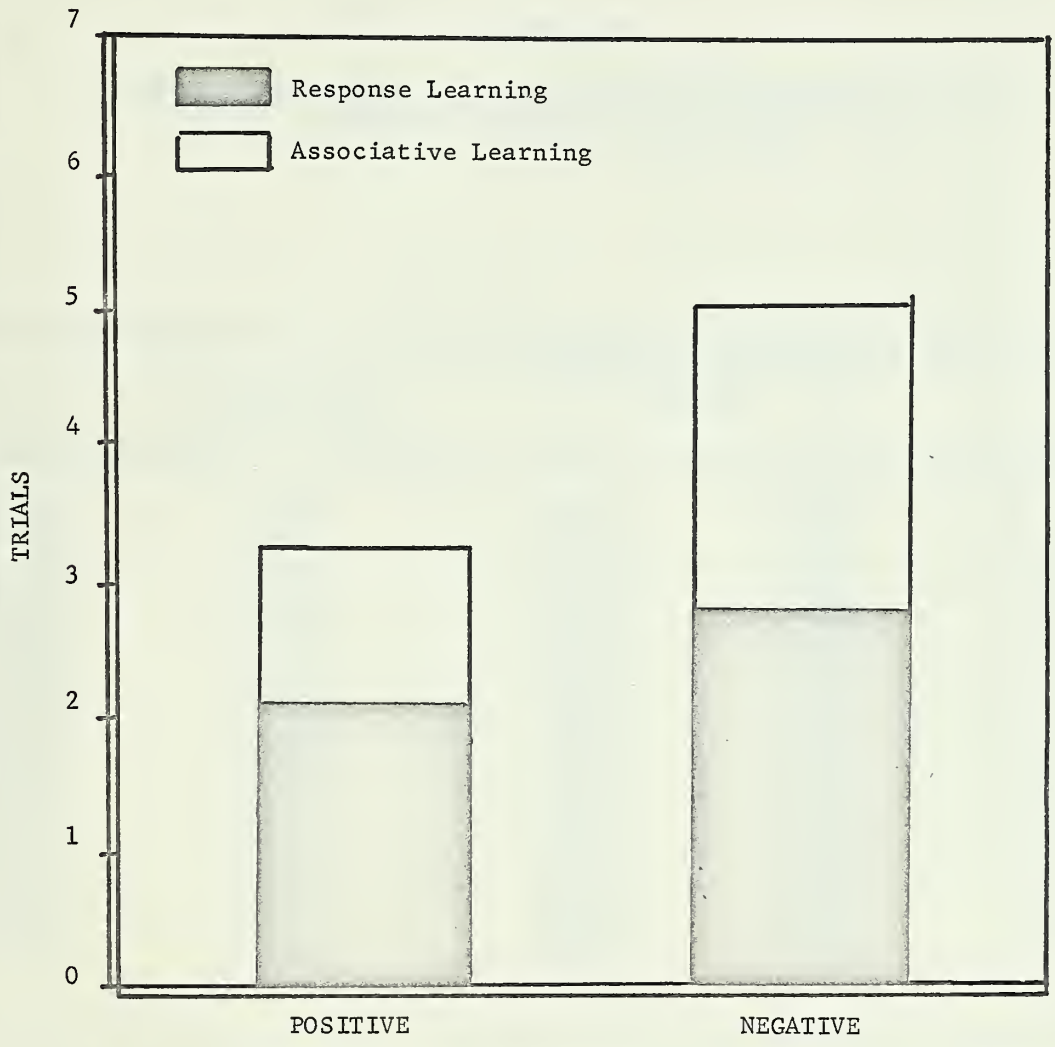

Figure 4. Experiment II. Mean Number of Trials Required to Complete Stages One and Two During OL - Positive and Negative Conditions.

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Appendix E

COMPARISONS AMONG SIX GROUPS IN OL OF EXPERIMENT I USING DUNCAN'S MULTIPLE RANGE TEST[1]

Groups	Difference Between Groups	Shortest Significant Range .05	.01	Conclusion
2P > 1N	4.250	1.599	2.084	$p < .01$
2P > 2N	3.500	1.569	2.059	$p < .01$
2P > CP	2.500	1.539	2.014	$p < .01$
2P > CN	1.250	1.489	1.959	N.S.
2P > 1P	0.333	1.414	1.879	N.S.
1P > 1N	3.917	1.569	2.059	$p < .01$
1P > 2N	3.1667	1.539	2.014	$p < .01$
1P > CP	2.1667	1.489	1.952	$p < .01$
1P > CN	0.9167	1.414	1.879	N.S.
CN > 1N	3.000	1.539	2.014	$p < .01$
CN > 2N	2.250	1.489	1.959	$p < .01$
CN x CP	1.250	1.414	1.879	N.S.
CP > 1N	1.750	1.489	1.959	$p < .05$
CP > 2N	1.000	1.414	1.879	N.S.
2N > 1N	0.750	1.414	1.879	N.S.

1. Total number of correct responses on the last learning trial were used as scores. In Appendixes E, F and G, the direction of the sign between abbreviations for groups indicates the direction of the predicted difference; "x" is used where no difference is predicted; nonsignificant is abbreviated N.S.

Appendix F

COMPARISONS AMONG SIX GROUPS ON FIRST RECALL TRIAL IN EXPERIMENT I USING DUNCAN'S MULTIPLE RANGE TEST[1]

Groups	Difference Between Groups	Shortest Significant Range .05	.01	Conclusion
1P > 1N	3.667	2.081	2.712	p < .01
1P > 2N	3.167	2.042	2.680	p < .01
1P > CP	2.083	2.003	2.621	p < .05
1P > CN	1.833	1.938	2.550	N.S.
1P > 2P	0.417	1.841	2.446	N.S.
2P > 1N	3.250	2.042	2.680	p < .01
2P > 2N	2.750	2.003	2.621	p < .01
2P > CP	1.667	1.938	2.550	N.S.
2P > CN	1.417	1.841	2.446	N.S.
CN > 1N	1.833	2.003	2.621	N.S.
CN > 2N	1.333	1.938	2.550	N.S.
CN x CP	0.250	1.841	2.446	N.S.
CP > 1N	1.583	1.938	2.550	N.S.
CP > 2N	1.083	1.841	2.446	N.S.
2N > 1N	0.500	1.841	2.446	N.S.

1. Total number of correct responses of the first recall trial were used as scores.

Appendix G

COMPARISONS AMONG SIX GROUPS IN RELEARNING OF EXPERIMENT I USING DUNCAN'S MULTIPLE RANGE TEST[1]

Groups	Difference Between Groups	Shortest Significant Range .05	Shortest Significant Range .01	Conclusion
1N > 2P	7.417	3.706	4.829	$p < .01$
1N > 1P	7.083	3.636	4.771	$p < .01$
1N > CN	4.667	3.567	4.667	$p < .01$
1N > CP	1.417	3.451	4.539	N.S.
1N > 2N	0.083	3.277	4.354	N.S.
2N > 2P	7.333	3.636	4.771	$p < .01$
2N > 1P	7.000	3.567	4.667	$p < .01$
2N > CN	4.583	3.451	4.539	$p < .01$
2N > CP	1.333	3.277	4.354	N.S.
CP > 2P	6.000	3.567	4.667	$p < .01$
CP > 1P	5.667	3.451	4.539	$p < .01$
CP x CN	3.250	3.277	4.354	N.S.
CN > 2P	2.750	3.451	4.539	N.S.
CN > 1P	2.417	3.277	4.354	N.S.
1P > 2P	0.333	3.277	4.354	N.S.

1. Total number of trials to relearn to a criterion of one perfect trial were used as scores.

Appendix H

COMPARISON OF IDENTICAL S-R PAIRS IN EXPERIMENT II[1]

Pair	t with 19 df
TABLE--BIW	7.9595**
TABLE--RUQ	3.7283**
DARK--ZAF	4.9911**
DARK--GEJ	3.3557**
NAIL--GEJ	4.0363**
NAIL--ZAF	1.6441
QUEEN--RUQ	1.7298
QUEEN--BIW	2.6112*

N = 20 * $p < .05$ ** $p < .01$

1. Total number of correct responses during OL were used as scores.

Appendix I

RAW DATA

Subjects[1]	Groups					
	1P	2P	CP	CN	2N	1N
Number of Correct Responses on Final OL Trial in Experiment I[2]						
1AE	8	8	0	2	5	2
2AE	6	8	5	4	5	0
3AE	6	7	7	6	3	4
4AC	8 (8)	4 (3)	7 (8)	5 (4)	6 (8)	4 (3)
5AC	4 (8)	8 (8)	5 (6)	8 (7)	1 (5)	3 (2)
6AC	8 (8)	8 (8)	1 (5)	5 (4)	1 (2)	2 (2)
7BE	6	7	5	7	3	5
8BE	7	6	3	5	5	0
9BE	6	8	5	6	4	4
10BC	5 (2)	7 (8)	4 (3)	6 (8)	2 (3)	2 (5)
11BC	7 (7)	8 (8)	7 (6)	6 (6)	1 (2)	4 (5)
12BC	7 (8)	3 (5)	3 (5)	7 (7)	4 (4)	1 (5)
Number of Correct Responses on First Recall Trial in Experiment I						
1AE	8	1	1	0	7	2
2AE	2	5	6	4	2	0
3AE	4	6	5	5	1	2
4AC	8	4	8	3	5	4
5AC	4	8	6	5	2	2
6AC	8	7	3	7	2	2
7BE	8	8	2	3	1	2
8BE	8	6	0	1	3	0
9BE	2	4	3	8	3	1
10BC	6	8	3	3	2	4
11BC	5	8	8	6	2	4
12BC	8	1	1	4	3	4

1. The first letter after the S's number refers to the List (A or B) that S received; E and C refer to experimental and control Ss, respectively.

2. The numbers in parentheses refer to the number of correct responses given by the Immediate-Recall Ss on the one recall trial administered immediately upon completion of OL.

Appendix I (continued)

Subjects	Groups					
	1P	2P	CP	CN	2N	1N
Number of Correct Responses on Final Recall Trial in Experiment I						
1AE	8	2	1	0	8	2
2AE	3	6	7	6	1	0
3AE	8	8	5	5	3	4
4AC	8	4	8	2	5	4
5AC	4	8	6	6	2	2
6AC	8	8	4	7	2	2
7BE	8	8	3	5	1	3
8BE	8	8	0	1	3	0
9BE	8	4	6	8	2	3
10BC	6	8	4	6	4	6
11BC	3	8	7	8	2	7
12BC	8	4	3	5	3	6
Number of Trials Required to Relearn to Criterion in Experiment I						
1AE	1	3	15	15	1	8
2AE	5	2	2	5	6	15
3AE	1	1	9	2	15	15
4AC	1	2	1	8	3	11
5AC	4	1	3	3	12	15
6AC	1	1	7	2	7	10
7BE	1	1	15	4	15	2
8BE	1	1	9	5	3	15
9BE	2	2	4	1	12	13
10BC	6	1	15	2	7	3
11BC	2	1	5	2	15	3
12BC	1	5	8	5	8	3

Subjects	Final OL Trial	Projected OL Score	First Recall	Tenth Recall	Trials Relearn
Number of Correct Responses, Projected Scores, and Number of Trials to Relearn for First Association Positive Group (List A) in Experiment II					
1	7	7.38	6	6	2
2	6	6.66	8	8	1
3	8	7.38	8	8	1
4	4	6.59	6	6	3
5	2	5.61	3	4	6
6	5	6.00	4	6	3
7	8	6.77	4	8	1

Appendix I (continued)

Subjects	Final OL Trial	Projected OL Score	First Recall	Tenth Recall	Trials Relearn
Number of Correct Responses, Projected Scores, and Number of Trials to Relearn for First Association Positive Group (List A) in Experiment II (continued)					
8	8	7.17	8	8	1
9	7	6.21	3	5	2
10	8	7.24	7	8	1
11	8	7.50	5	8	1
12	7	7.50	8	8	1
13	7	7.13	8	8	1
14	6	7.09	6	8	1
15	8	7.41	5	8	1
16	7	7.42	7	8	1
17	8	6.54	6	8	1
18	8	6.60	3	4	3
19	8	7.61	6	6	2
20	8	7.47	7	8	1
Number of Correct Responses, Projected Scores, and Number of Trials to Relearn for First Association Positive Group (List B) in Experiment II					
21	3	5.04	2	2	7
22	7	6.57	7	8	1
23	7	6.83	4	4	8
24	6	6.64	8	8	1
25	6	6.31	6	8	1
26	8	7.12	4	6	2
27	1	4.66	0	0	6
28	6	5.95	7	7	1
29	7	6.91	8	8	1
30	6	6.28	4	4	2
31	7	7.31	8	8	1
32	7	6.60	7	8	1
33	7	7.40	5	6	2
34	2	5.44	0	0	13
35	2	6.25	3	2	4
36	7	7.36	3	3	4
37	7	7.29	8	8	1
38	8	7.32	6	8	1
39	8	6.60	5	6	2
40	4	5.57	4	2	6

Appendix I (continued)

Subjects	Final OL Trial	Projected OL Score	First Recall	Tenth Recall	Trials Relearn
Number of Correct Responses, Projected Scores, and Number of Trials to Relearn for First Association Negative Group (List A) in Experiment II					
1	2	3.50	2	2	7
2	4	3.23	1	2	15
3	3	3.39	0	0	15
4	4	5.25	2	1	7
5	1	1.81	0	0	15
6	1	1.69	2	2	11
7	5	5.81	4	4	12
8	1	1.57	0	0	8
9	3	3.58	3	3	12
10	3	4.65	1	3	12
11	1	1.26	1	1	15
12	3	3.70	2	2	8
13	5	5.13	3	3	8
14	2	2.56	3	4	8
15	5	4.34	3	3	12
16	5	4.18	2	3	15
17	5	4.05	3	3	8
18	6	5.94	6	5	7
19	3	3.58	0	0	14
20	2	1.73	1	1	15
Number of Correct Responses, Projected Scores, and Number of Trials to Relearn for First Association Negative Group (List B) in Experiment II					
21	5	4.98	3	3	15
22	4	4.70	2	5	3
23	4	3.50	3	3	12
24	2	2.44	2	2	15
25	5	3.94	3	4	4
26	5	5.52	2	3	6
27	5	4.03	3	6	3
28	5	4.65	2	2	7
29	4	3.67	5	7	6
30	4	3.50	2	1	15
31	5	4.31	4	5	7
32	3	2.52	1	2	13
33	7	5.41	4	2	8
34	2	2.69	1	2	15
35	2	2.28	0	3	8
36	5	6.24	6	7	3
37	4	4.97	0	0	15
38	2	4.27	2	3	14
39	2	1.73	1	3	12
40	3	2.28	2	3	9

REFERENCES

REFERENCES

Barnes, Jean M., & Underwood, B. J. "Fate" of first-list associations in transfer theory. J. exp. Psychol., 1959, 58, 97-105.

Briggs, G. E. Acquisition, extinction and recovery functions in retroactive inhibition. J. exp. Psychol., 1954, 47, 285-293.

Bugelski, B. R., & Scharlock, D. P. An experimental demonstration of unconscious mediated association. J. exp. Psychol., 1952, 44, 334-338.

Goss, A. E., Morgan, C. H., & Golin, S. J. Paired-associates learning as a function of percentage of occurrence of response members. J. exp. Psychol., 1959, 57, 96-104.

Glaze, J. A. The association value of non-sense syllables. J. Genet. Psychol., 1928, 35, 255-267.

Haagen, C. H. Synonymity, vividness, familiarity, and association value ratings for 400 pairs of common adjectives. J. Psychol., 1949, 27, 453-463.

Horton, D. L., & Kjeldergaard, P. M. An experimental analysis of association factors in mediated generalization. Psychol. Monogr., 1961, 75, No. 11.

Jenkins, J. J. Mediated associations: Paradigms and situations. In C. N. Cofer and Barbara S. Musgrave (eds.), Verbal behavior and learning. New York: McGraw-Hill, 1963. Pp. 210-244.

Kaplan, R. J. A study of semantic generalization through the use of established conceptual mediators. J. exp. Psychol., 1959, 57, 288-293.

Koppenaal, R. J. Times changes in the strengths of A-B, A-C lists; Spontaneous recovery? J. verbal Learn. verbal Behav., 1963, 2, 310-319.

Lewis, D. Quantitative methods in psychology. New York: McGraw-Hill, 1960.

Mandler, G. Response factors in human learning. Psychol. Rev., 1954, 61, 235-244.

McGehee, Nan E., & Schulz, R. W. Mediation in paired-associate learning. J. exp. Psychol., 1961, 62, 565-570.

McGovern, Jean B. Extinction of associations in four transfer paradigms. Psychol. Monogr. (in press).

McGeoch, J. A. The influence of degree of interpolated learning upon retroactive inhibition. Amer. J. Psychol., 1932, 44, 695-708.

Melton, A. W., & Irwin, J. McQ. The influence of degree of interpolated learning on retroactive inhibition and the overt transfer of specific responses. Amer. J. Psychol., 1940, 53, 173-203.

Morgan, R. L., & Underwood, B. J. Proactive inhibition as a function of response similarity. J. exp. Psychol., 1950, 40, 592-603.

Osgood, C. E. Meaningful similarity and interference in learning. J. exp. Psychol., 1946, 36, 277-301.

Osgood, C. E. An investigation into the causes of retroactive interference. J. exp. Psychol., 1948, 38, 132-154.

Postman, L. The present status of interference theory. In C. N. Cofer (ed.), Verbal learning and verbal behavior. New York: McGraw-Hill, 1961. Pp. 152-179.

Postman, L. Does interference theory predict too much forgetting? J. verbal Learn. verbal Behav., 1963, 2, 40-48.

Reed, H. B. Factors influencing the learning and retention of concepts. I. The influence of set. J. exp. Psychol., 1946, 36, 71-87.

Richardson, J. The relationship of stimulus similarity and number of responses. J. exp. Psychol., 1958, 56, 478-484.

Richardson, J. Association among stimuli and the learning of verbal concept lists. J. exp. Psychol., 1960, 60, 290-298.

Richardson, J., & Underwood, B. J. Comparing retention of verbal lists after different rates of acquisition. J. gen. Psychol., 1957, 56, 187-192.

Russell, W. A., & Jenkins, J. J. The complete Minnesota norms for responses to 100 words from the Kent-Rosanoff Word Association Test. Tech. Rep. No. 11, 1954. Contract No. N8 ONR-66216. Office of Naval Research and University of Minnesota.

Russell, W. A., & Storms, L. H. Implicit verbal chaining in paired-associate learning. J. exp. Psychol., 1955, 49, 267-293.

Steel, Robert G. D., and Torrie, J. H. Principles and procedures of statistics. New York: McGraw-Hill, 1960.

Thorndike, E. L., & Lorge, I. The teacher's word book of 30,000 words. New York: Bureau of Publications Teachers College, Columbia University, 1959.

Thune, L. E., & Underwood, B. J. Retroactive inhibition as a function of degree of interpolated learning. J. exp. Psychol., 1943, 32, 135-200.

Underwood, B. J. Retroactive and proactive inhibition after five and forty-eight hours. J. exp. Psychol., 1948, 38, 29-38. (a)

Underwood, B. J. "Spontaneous recovery" of verbal associations. J. exp. Psychol., 1948, 38, 429-439. (b)

Underwood, B. J. Proactive inhibition as a function of time and degree of prior learning. J. exp. Psychol., 1949, 39, 24-43.

Underwood, B. J. Speed of learning and amount retained: A consideration of methodology. Psychol. Bull., 1954, 51, 276-282.

Underwood, B. J. Interference and forgetting. Psychol. Rev., 1957, 64, 49-60.

Underwood, B. J. An evaluation of the Gibson theory of verbal learning. In C. N. Cover (ed.), Verbal learning and verbal behavior. New York: McGraw-Hill, 1961. Pp. 197-217.

Underwood, B. J., Duncan, C. P., Taylor, Janet A., & Cotton, J. W. Elementary Statistics. New York: Appleton-Century-Crofts, Inc., 1954.

Underwood, B. J., & Hughes, R. H. Gradients of generalized verbal responses. Amer. J. Psychol., 1950, 63, 422-430.

Underwood, B. J., & Keppel, G. An evaluation of two problems of method in the study of retention. Amer. J. Psychol., 1962, 75, 1-17.

Underwood, B. J., Runquist, W. N., & Schulz, R. W. Response learning in paired-associate lists as a function of intra-list similarity. J. exp. Psychol., 1959, 58, 70-78.

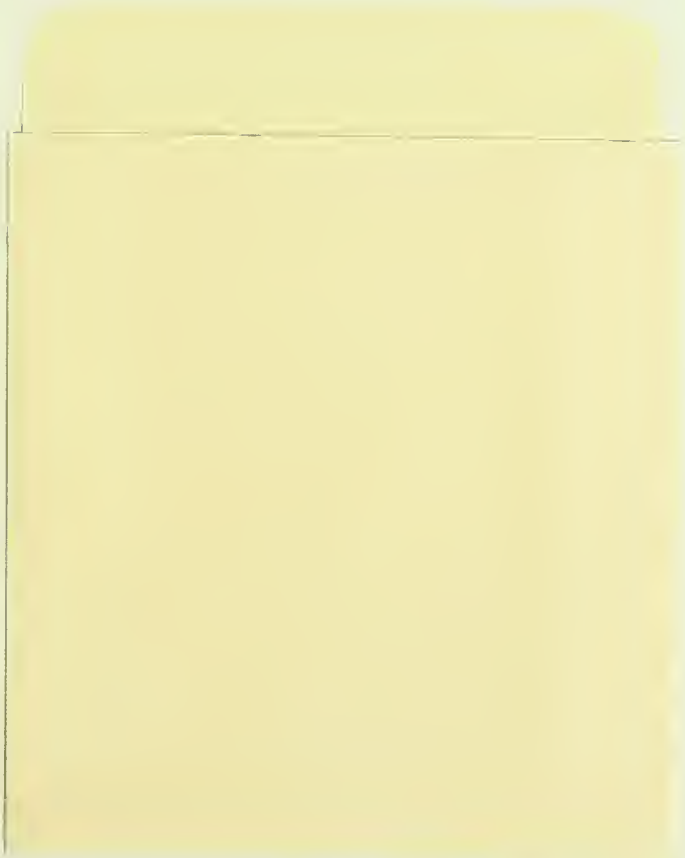
Underwood, B. J., & Schulz, R. W. Meaningfulness and verbal learning. Chicago: Lippincott, 1960.

Winer, B. J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.

Young, R. K. Retroactive and proactive effects under varying conditions of response similarity. J. exp. Psychol., 1955, 50, 113-119.

BIOGRAPHY

Name:	Robert William Holmstrom, Jr.
Date of Birth:	August 13, 1934
Place of Birth:	Hartford, Connecticut
Education:	Trinity College, Hartford, Connecticut, 1952-1956. B.A., June, 1956.
	Duke University, Durham, North Carolina, September, 1959-June, 1965.
Positions:	James B. Duke Fellow, Duke University, September, 1960-June, 1961.
	Psychology Trainee, Veterans Administration Hospital, Durham, North Carolina (half-time), September, 1962-June, 1963.
	USPHS Predoctoral Fellow, Duke University, July, 1963-June, 1964.
	Psychology Intern (USPHS Fellow), Duke Medical Center, September, 1964-August, 1965.



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